ILLUMINATING ENGINEERING

MARCH 1956

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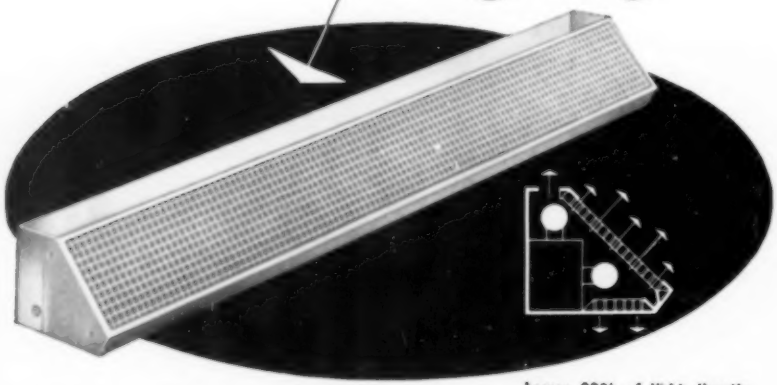

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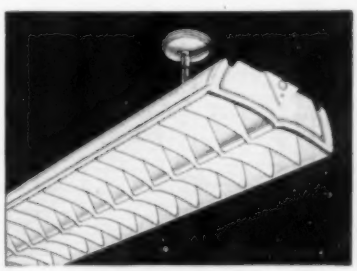

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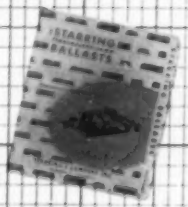

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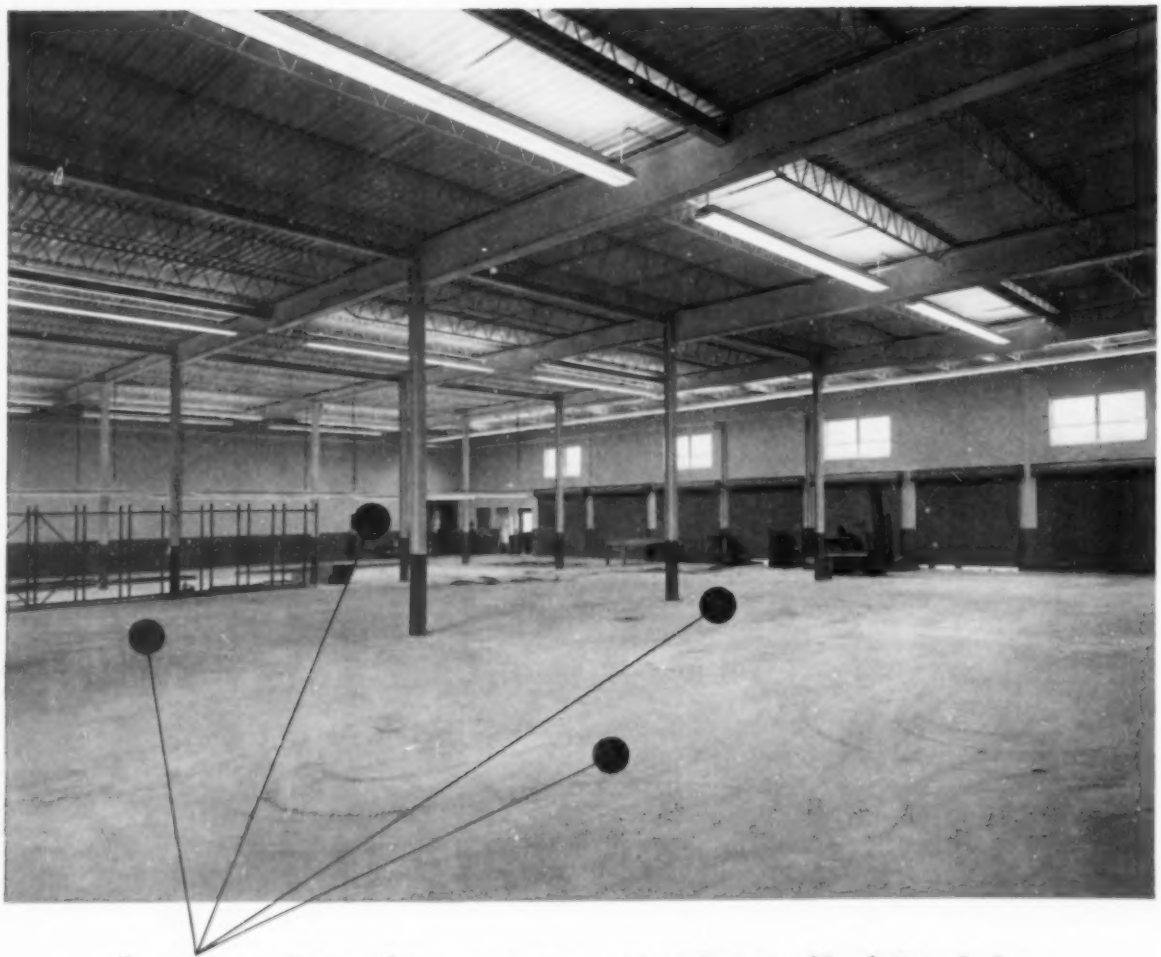

four areas here are custom lighted by **Litecontrol**

Variations in height and spacing of a single LITECONTROL fixture give each of the four working areas on this warehouse floor just the right light for its needs. Intensity is low in the heavy storage area (foreground), higher over the accessories racks (background). Other work areas, each custom lighted, are the assembly line (near the rear wall) and the loading area (by the doors).

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AREA: Warehouse

PROJECT ENGINEER: Alex M. Engart, Engineering Dept., Marketing Division, Sun Oil Company

ELEC. CONTRACTOR: Helldoerfer-Castellini, Dayton, Ohio

FIXTURES: Litecontrol No. 2428 2-lamp slimline industrial

MOUNTING HEIGHT: 17'-6" and 9'-0"

INTENSITIES: Over storage racks (foreground), 15 Footcandles in service — Accessories racks (low fixtures, background), 35 Footcandles in service — Motor Oil Assembly lines (background), 25 Footcandles in service — Loading area (near doors) 15-20 Footcandles in service

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DESIGNERS, ENGINEERS AND MANUFACTURERS OF FLUORESCENT LIGHTING EQUIPMENT DISTRIBUTED ONLY THROUGH ACCREDITED WHOLESALERS

Acrylic Louver Wall Panels For Classroom Daylighting

By E. M. LINFORTH

VARIOUS arrangements of horizontal or vertical slats have been used for a long time to control sunlight and heat in buildings. The modern counterpart of the centuries-old venetian blind hung from the window head inside the building is certainly the commonest form of louvers in use today. Less common, but appearing with increasing frequency as the footcandle yields to the footlambert, are exterior louvers made of wood or metal, even concrete, supported from the wall or suspended from roof projections. The subject of this research, here reported in preliminary fashion for the first time, is a new form of louver which is applied neither inside nor outside the window but is in fact the window itself (Fig. 1). These louvers, or more properly, louvered wall panels, are made of transparent acrylic plastic sheet by the ridge-forming process thereby providing slat surfaces and weather closure in one continuous surface. The slats are opaqued by the spray application of pigmented acrylic lacquer on the indoor side.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 12-16, 1955, Cleveland, Ohio. AUTHOR: Rohm and Haas Co., Philadelphia, Pa.

The Test Building

A program of evaluation and experimentation was initiated in June 1954 in order to learn something about louver wall panel performance, qualitatively and quantitatively, in relation to room architecture, mounting height, outdoor surround and the variable sources. To this end a small rotatable building was erected in a field adjacent to the Bristol, Pennsylvania laboratories (Fig. 2). It is 16 feet square and 7 ft 8 inches to the underside of the rafters, beneath which the ceiling height and inclination is adjustable and a movable partition permits varying the room depth, thus making it possible to reproduce typical classroom proportions at half scale. The building is mounted with the floor two feet above the ground on an 8-foot diameter turntable. Ceiling, wall, and floor reflectances were 80, 72 and 22 per cent respectively and were not changed throughout the tests.

Instrumentation

Instrumentation consisted of twelve barrier layer photo cells, eye sensitivity and cosine cor-

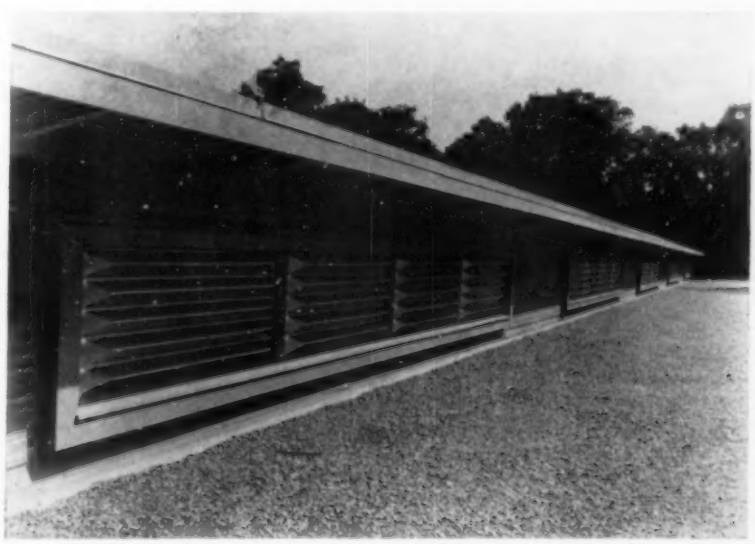

Figure 1. Formed acrylic louver panels at the Katharine Smith School, Houston, Texas. The roof projection is superfluous but does not seriously reduce efficiency because of high utilization of light reflected from the roof.

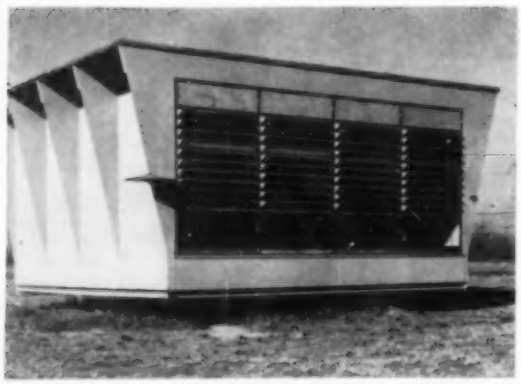

Figure 2. Forty-five-degree louver panels in the rotatable test building at Bristol, Pennsylvania. Spring clips and adjustable framing facilitate changing fenestration. Photocell at the right measures total illumination on the vertical plane and the hooded one on the left measures the ground reflected component.

rected. Four were mounted on a traverse bar supported by wheels and tracks in the horizontal work plane 30 inches above the floor. (This and all dimensions to follow are given at full scale.) The cells were mounted at either end in the vertical plane and two fixed to the rear wall to provide brightness data in terms of illumination times the wall reflectance factor. These cells were connected to a single half per cent microammeter through a selector switch. These details are shown in Fig. 3. Two hermetically sealed fully corrected photo cells were mounted outside in the window plane, one to measure total illumination and the other hooded to measure light from below the horizon. Both cells were connected to a second half per cent meter through a selector switch. A Macbeth illuminometer was used for calibration of the E_t photocell, the cell used to measure total illumination on the vertical plane of the windows. This cell was then used as a standard for the calibration of the other cells. Louver panel brightneses were measured with a Spectra meter with half degree acceptance angle.

The locations of the outdoor cells, clearly shown in Fig. 2, are not entirely satisfactory. They receive more or less light on certain sun bearings than the middle of the window wall, because of the nonuniformity of the shadow pattern beneath the windows and the cell locations at the sides. The error in the total illumination measurements is negligible but large enough in the case of ground light measurements at 180-degree bearing to require the use of a correction factor, which was determined empirically. For every indoor observation the corresponding outdoor illumination, both total and ground reflected was recorded.

Figure 3. Interior arrangement of the test building permits adjustment to the dimensions of typical classrooms at half scale. Photocells are mounted on a traverse which is operated from the meter panel location outside of the room.

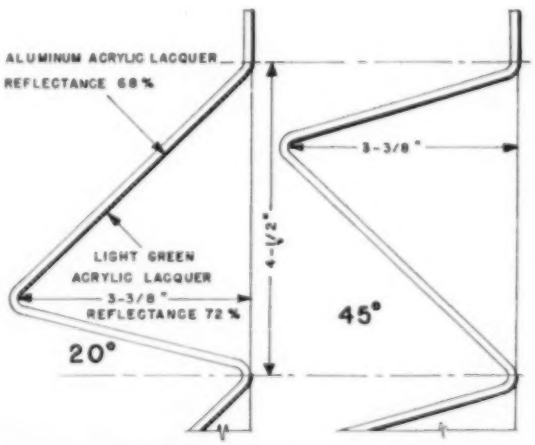

Figure 4. Vertical sections showing the geometry of the two louver configurations tested.

To keep track of sun elevations and bearings on the window wall, a sun angle protractor consisting of a simple acrylic lens and a translucent disc 2 ft 0 in in diameter calibrated annularly for elevation and radially for bearings was devised and installed in the roof above the meter panel. When

viewed from below an image of the sun appears as a bright spot about ⅛ inch in diameter on the translucent disc, and elevation and bearing can be read directly.

Louver Performance

A great deal of information on the performance of louver panels of two geometries, oriented vertically as well as horizontally and at several mounting heights has been accumulated. However, only data pertaining to systems considered to be of most general interest is presented here. The louver panels used in these systems differed only in angle of cut-off. The slats were opaqued with aluminum lacquer on the inner surfaces followed by a second coat of pale green lacquer. The reflectance of the aluminum coat measured through the transparent plastic and illuminated by an overcast sky was 68 per cent. The reflectance of the green interior finish coat was 72 per cent.

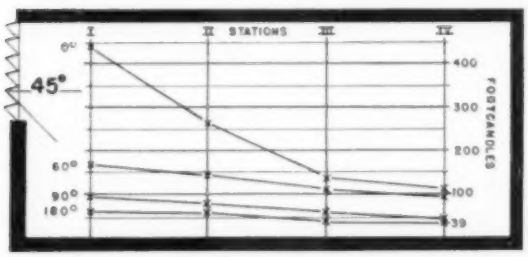

Figure 5. Average illumination on the work plane provided by the 45-degree louvers at the four traverse stations on a clear day for four bearing angles of the sun. Altitude 45 degees — 47 degrees. Total illumination on the vertical plane at each bearing was: 0-degree, 6500 footcandles; 60-degree, 3500 footcandles; 90-degree, 1500 footcandles; 180-degree, 800 footcandles.

Series 1 (Fig. 5) and Series 2 (Fig. 6) are precisely the same in all respects with the exception of the angles of cut-off of the louver panels. They are directly comparable and reveal the quantitative difference between louver panels of 45-degree and 20-degree cut-off angles on four orientations of the building in respect to the sun at an elevation of 47 degrees. The test data, in terms of footcandles, were converted to per cents of the corresponding total illumination on the window plane and were then applied to the average total illumination on the windows at each bearing. Bearing, as used here, is the angle measured in the plane of the horizon through which a vertical plane making a right angle with the window plane must be rotated to contain the sun. The average illuminations at

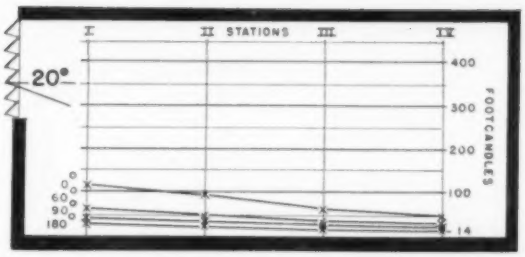

Figure 6. Average illumination on the work plane provided by the 20-degree louver panels under the same conditions as the 45-degree louvers in Fig. 5.

the four bearings were: 0 degree, 6500 footcandles; 60 degrees, 3500 footcandles; 90 degrees, 1500 footcandles; 180 degrees, 800 footcandles. The room dimensions were as follows: window wall, 32 ft 0 in; window wall to rear wall, 24 ft 0 in; ceiling height 11 ft 0 in; louver panel mounting height 6 ft 0 in.

The brightnes data in Fig. 7 pertains to the 20-degree louver panels in the same room architecture as used in Series 1 and 2. It is the ratio of the brightness of the spots indicated to the task brightnes taken as 70 per cent of the minimum illumination on the working plane on a clear day with the sun at 0-degree bearing and 51-degree elevation. During the observations the task illumination varied between 38 and 42 footcandles, however, spot brightness and illumination were measured simultaneously, hence, the ratios are comparable.

One bilateral system has been studied so far and the results are shown in Fig. 8. In this third series of tests the room dimensions were: window walls, 32 ft 0 in; side walls, 24 ft 0 in; ceiling height — high side, 12 ft 6 in; low side, 8 ft 0 in. The 20-degree louver panels were used on both sides and were mounted on the high side at 8 ft 6 in and at 5 ft 6 in on the low side.

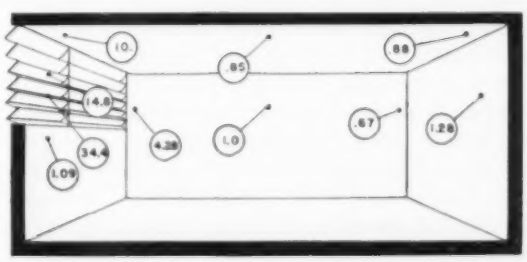

Figure 7. Ratios of the brightness of the locations indicated to the task (70 per cent of the minimum work plane illumination) resulting from the 20-degree louvers with the sun at 0-degree bearing, altitude of 51-degree and total illumination on the window wall of 5700 footcandles.

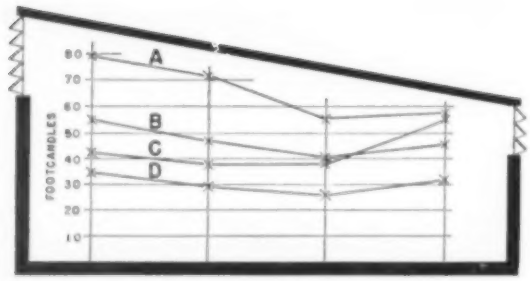

Figure 8. Average illumination on the work plane at each station provided by the 20-degree louvers under the following conditions.

A. Sun at 0-degree bearing, 50-degree elevation on high side. Total illumination: high side, 6100 footcandles; low side, 970 footcandles.

B. No direct sun on louvers, clear sky. Total illumination: high side, 1200 footcandles; low side, 1050 footcandles.

C. Sun at 0-degree, 67-degree elevation on low side. Total illumination: low side, 4200 footcandles; high side, 800 footcandles.

D. Overcast sky. Total illumination: high side, 1460 footcandles; low side, 1000 footcandles.

Curve A shows the average illumination at each traverse station with the sun at an elevation of 50 degrees and 0-degree bearing on the high side on a slightly hazy day giving a total almost constant illumination of 6100 footcandles on the high window plane and 970 footcandles on the low side.

Curve B shows the average illumination at the four stations with no direct sun on either side and a total illumination on the high side of 1200 footcandles and low side 1050 footcandles.

Curve C shows illumination with the sun at 67-degree elevation and 0-degree bearing on the low side on a clear day. Total illumination on the high side was 800 footcandles and on the low side 4200 footcandles.

Curve D shows illumination with a nonuniform overcast sky resulting in 1000 footcandles on low louvers and 1460 footcandles on the high louvers.

Fig. 9 shows brightness data for the Series 3 system. The upper figures in the circles are the ratios of the spots indicated to the minimum task brightness of 39 footlamberts (70 per cent of minimum work plane illumination) with the sun at an elevation of 64 degrees and 0-degree bearing on the high side, resulting in a vertical surface illumination of 4190 footcandles on this side and 850 footcandles on the low louvers.

The lower figures are the ratios of the brightness of the spots indicated to a minimum task brightness of 25 footlamberts resulting from the sun shining on the low side from an elevation of 55 degrees at 0-degree bearing. Total illumination on the low side was 5000 footcandles and 890 footcandles on the high side.

Ground Light Utilization

As the data derived from a large number of observations of louver panel performance versus sun bearing and elevation were reviewed, it quickly became apparent that a larger percentage of ground light than sky or direct sunlight was reaching the working plane. It could be assumed that louver panels would favor the transmittance of light from near the horizon as opposed to the zenith because of their basic geometry but the full extent of ground light utilization was not appreciated until the pertinent data were analyzed and some additional observations made. Study of the ground plane surrounding the building revealed that it was an approximately uniform diffuse reflector with an efficiency of 10.6 to 11.4, hence it could be assumed that the ratio of the ground light component on the work plane to the ground light component on the window wall was constant and ground light utilization factors for the 20-degree louver panels, mounted at a height of 6 ft 0 in with the ceiling horizontal at 11 ft 0 in were found by a graphical procedure. The average illumination at each station was plotted as a function of the ground illumination on the window wall. Only data obtained at a 90-degree bearing with clear and overcast skies were used in order to eliminate the variables introduced by sun angles in relation to louver and building geometry and by building shadows at bearings greater than 90 degrees. The results are shown in Fig. 10. The slight scatter of the points probably resulting from minor differences in sky brightness patterns, ground reflectances and observation accuracy, is considered

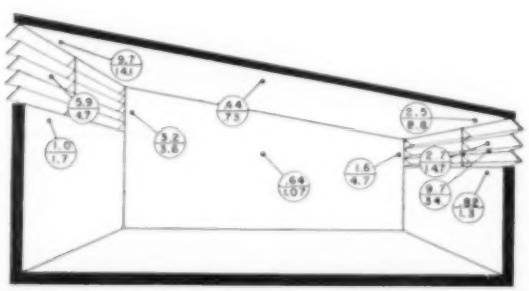

Figure 9. Ratios of brightness of areas indicated to task (70 per cent of minimum illumination). Upper figures: sun on high side at 0-degree bearing 64-degree elevation. Total illumination: high side, 4190 footcandles, low side, 850 footcandles. Lower figures: sun on low side at 0-degree bearing, 55-degree elevation. Total illumination: low side, 5000 footcandles; high side, 890 footcandles.

negligible and lines can reasonably be drawn through each group in view of the fact that only the slopes of the lines are significant and not their positions relative to the axes. It is, of course, not reasonable to extrapolate the ordinate to 1.0 because of the presence of sky light throughout. Utilization factors, the slopes of each group of points, so obtained are: Station I, .123; II, .078; III, .047; IV, .038. Application of these factors to the data indicate that the 20-degree louver panels under the test conditions transmit light reflected from the ground plane to each station in the work plane with an efficiency ten times the efficiency of skylight transmittance.

Having determined utilization factors in relation to a ground plane of almost uniform brightness from foreground to horizon a series of observations were made to obtain an indication of what might be called zonal efficiencies. On a cloudless day, the building was oriented so that the sun was at 90-degree bearing on the louver wall. The average illumination on the work plane and the ground component on the plane of the louvers were measured. Illumination on the horizontal plane measured by the photocell on the roof was the control. A strip of white blotting paper of 92 per cent reflectance was then placed on the ground immediately below the windows so that it covered an area extending the length of the window wall and projecting 3 ft 0 in therefrom and average illumination indoors in relation to E_h and E_g again determined. The high reflectance area was then moved progressively outward on the center line of the windows by increments of three feet and measurements made at each of six locations. The variations in average work plane illumination in relation to the high reflectance area locations as well as variation in the ground component on the window wall are shown in Fig. 11. The locations are plotted in terms of the angle between the vertical center line of the windows and a line from the mid point thereof to the middle of the area, and the illumination in footcandles corrected to the illumination on the horizontal plane at the beginning of the observations.

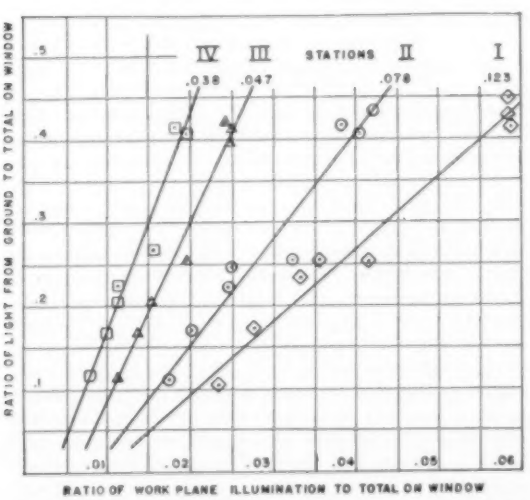

Figure 10. Graphical determination of ground light utilization factors for each station for the 20-degree louvers mounted at 6 ft 0 in with horizontal ceiling at 11 ft 0 in.

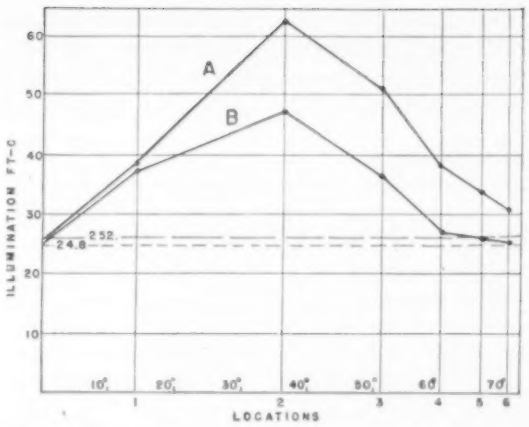

Figure 11. Ground illumination x 10^{-1} on the plane of the louvers, *A*, and average illumination on the work plane, *B*, in relation to the location of the high-reflectance patch on the ground plane.

The practical significance of the data is that the zones which contribute most to the ground component on the work plane lie well within the area of the architect's normal responsibility and that by the use of materials of relatively high reflectance in the right places, substantially higher levels of indoor illumination can be achieved than those obtained in Series 2. For example, if the increases in the average illumination on the work plane derived from the first three locations are added to the initial illumination of 24.8 footcandles it is apparent that the total illumination would be increased to 70.8 footcandles by an area of 92 per cent reflectance extending 9 ft 0 in from the window wall. The ratio of this increase of 46 footcandles to the increase of 1254 footcandles in the ground component is .0367. Maintained reflectances as high as 92 per cent are impracticable outdoors; however, factors of .4 to .5 and higher are readily obtainable with common architectural materials. If a material of 45 per cent reflectance were substituted for the 92 per cent reflectance area and the factor .0367 is applied to the propor-

tional increase in the ground component of 613 footcandles, the increase in the average illumination on the work plane would be 22.5 footcandles or 90.7 per cent.

Conclusions

The 45-degree louvers will provide good distribution of illumination at relatively high levels but because of the wide bands of sky visible between the slats, this type is not appropriate for the control of daylight in classrooms and similar enclosures where the quality of the visual environment is critical. It should prove useful, however, as a means of reducing solar heat gain in buildings during the overheated summer months. This function of louver panels is being investigated and will be reported elsewhere.

Analysis of the data clearly indicates that the 20-degree louver panels in properly integrated architecture will provide an excellent visual environment. The uniformity of distribution of illumination offered by both unilateral and bilateral systems is extremely good, though the level is low in the unilaterally lighted room under some conditions. The ground light experiments, however, show that the average illumination on the work plane can be significantly increased by increases in ground reflectance which are well within practical limits. The brightness contrast ratios found in the bilaterally lighted room with the sun shining full on the clerestory louvers are all less than 10 to 1. With the sun on the panels on the low side, the brightness at three locations in relation to the task exceeds this limit. These locations are the ceiling on the high side adjacent to the louvers, the louver slats on the low side and the sky between the slats on the low side and the sky between the slats on the low side. The louver slats and the visible sky are the only offending areas in the unilaterally lighted room.

It is believed that these unfavorable ratios except sky to task, can be reduced to less than 10 to 1 by increasing the ground reflectance thereby increasing the task brightness without proportional increases in brightness of the initially excessive areas. This assumption is based on the fact that in all cases these surfaces are illuminated primarily by sun and sky light reflected by the slat below. This is substantiated by the relatively low brightness of the bottom slat which is illuminated only by light reflected from the ground, the wall below the louvers and interior surfaces. The brightness ratio of the transparent surfaces between the slats of 34 to 1 with the task brightnesses in both the unilaterally and bilaterally lighted rooms with the sun shining directly on the louvers is not entirely attributable to the sky seen through these surfaces but is in part due to direct sunlight which enters the transparent material through a lensic section at the outer edge of each louver and is "piped" into the transparent slats where it escapes contributing to the brightness of these surfaces. The cross-sectional configuration which produces this effect is the result of the method of manufacture of the test panels. It has been found that the application of a matte surface to the transparent areas will largely overcome this deficiency and at the same time, scatter the sky light resulting in a significant overall reduction of brightness. An alternative is lowering the cut-off angle to a point where the offending surfaces would not be visible when the panels are mounted above eye level. Both modifications will be evaluated in the test building to determine how they may affect other performance characteristics.

It should be noted that all observations were made without vision strips in the window wall. It is assumed, however, that they would be incorporated in typical louver panel installation, and that they would be glazed with low-transmittance material, 5 to 10 per cent depending on the orientation, to control brightness.

Louvered acrylic wall panels offer the architect and lighting specialist a new system of classroom daylighting free of many of the disadvantages normally associated with side-wall windows. Because reflected light from the ground plane is transmitted with much greater efficiency than light from above the horizon, the extreme variation in indoor illumination as the sun moves across the sky is greatly reduced and the brightness-balance of the visual environment maintained.

DISCUSSION

ERIC PAWLEY:* Is there any effect of deterioration of the reflective side of the louvers due to the aging of the acrylic? I understand that the reflective part is used in the slat above, that is, the light comes through due to that.

HOWARD KINGSBURY:** Mr. Linforth has certainly aided in presenting a considerable amount of interesting data about a new system. Apparently, however, the application of this system is somewhat limited. I say this on the basis of Figs. 5 and 6 and the author's comments on brightness control. Fig. 6 particularly shows that the utilization of exterior light is rather poor in comparison to other fenestration systems and materials, although its distribution is certainly excellent. If a vision strip is used in conjunction with the panels, it would be a normal circumstance. It is wise to point out that care must be exercised in the choice of material or shading used to prevent excessive brightness in this area, as the author points out, by the choice of high

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**Pittsburgh Corning Corp., Port Allegany, Pa.

reflectance ground materials to enhance the performance of the panels. This problem is frequently overlooked by architects and therefore deserves re-emphasis. Further, I would like to ask, in the test procedure was there any indication that the reduction in scale affects the results of whether materials, particularly glass block, and I don't know about some of the other systems — does reduction in scale cause problems of correlation with full size models?

J. W. GRIFFITH:* It is gratifying to see new interests in the field of daylighting. This new product should have many of the advantages of the venetian blind control as well as having the disadvantage of being a fixed control.

In reporting the data, only the total illumination on the vertical plane was given. It would be of great advantage for study purposes, if the author would give both the total illumination on the vertical as well as that portion of it that was obtained from below the horizontal. If readings were taken of the illumination from the sun only, this also would aid in the usefulness of these data.

If smaller scale models of the louvered wall panels could be constructed, a study of this type of fenestration under an artificial sky would simplify the testing procedure considerably. Such a study would permit the investigator to measure the effect of illumination from below the horizon, from above the horizon and from the sun separately.

A comparison of the utilization factors shown in Fig. 10 plotted versus feet from the fenestration produced a curve similar to that of the utilization factor for ground illumination through venetian blinds adjusted at 45 degrees and havng a reflectance of 70 per cent.

The low efficiency of the ground as a reflector is apparently due to dark green grass around th model. Were any of the tests taken with a higher reflective ground such as dry dead grass?

E. W. CONOVER:** This excellent paper presents performance data on a new product that is a welcome addition to daylighting information. It is indcated that tests are being continued and it is hoped that additional data will be presented later.

A study of this elicits some comments and questions that we present for the author's consideration. In Fig. 2 it appears that the hooded photocell for measuring ground reflected light may be receiving a considerable amount of light from the side walls of the model. Is this shielded to prevent such an addition from that source?

In the case of the 20-degree louver the ratio of the opaque portion to the 4½-inch spacing is about the same as for venetian blinds and it appears as though the results for this louver might be the same as for venetian blinds with slats of about 70 per cent reflectance set at 45 degrees.

We suggest that a larger scale for footcandles be used in future presentations than shown in Figs. 5 and 6 so that particularly the lower values may be read more accurately. Also that the position of the stations be dimensioned. In these illustrations they appear to be six feet apart and three feet from the walls. Is this correct?

It is gratifying to find that another investigator has found ground reflected light to be such an important factor. We have been of the opinion that the ground area in the immediate vicinity of the window wall was the most effective and Mr. Linforth's presentation points it out quite dramatically. In this regard it appears from the contour of the louvers that the effect would be different for the 45-degree louver than the 20-degree one as the ground area seen by the clear portion is determined by the slope of the opaque portion.

R. W. MCKINLEY:* This is an interesting new product and I have two questions:

(1) How would the results be influenced by an interior louver finish of, say, 20 per cent reflectance rather than the 72 per cent used?

(2) Reference is made on page 236 to low transmittance glazing in the 5- to 10-per cent range. Have the authors determined that this range is both adequate control-wise and aesthetically and psychologically acceptable?

BERNARD F. GREENE:** Mr. Linforth's paper is most interesting inasmuch as it introduces the use of acrylic for control in side wall lighting. I wonder, in connection with this approach, whether consideration had been given to mounting the control area shown in a movable fashion so as to obtain variation and at the same time give more flexibility and control. It would seem that the use of a fixed control element as indicated is much like putting a venetian blind in front of a window and keeping it down. Because of weather changes and the possibility of overcast as well as clear days, the proposed scheme penalizes the overall pattern of lighting in the room. I am sure there are many applications, such as clerestories and such, where the use of fixed panels of the type shown would have its application.

R. L. BIESELE, JR.:† This paper is a welcome contribution to the art of daylighting. The possibility of including the louver elements in the fenestration material is an interesting variant on louver techniques. In addition, the possibility of fabrication of these louvers in panels of considerable size would appear to offer cost advantages which might become quite attractive, particularly if the louver panels can be incorporated as part of a prefabricated wall panel assembly.

The brightness and illumination data of this paper should be readily applicable to other louver assemblies of similar geometry and reflectance characteristics. In this respect this paper offers some of the most comprehensive data available on louver controls. This should be of considerable value in architectural design and site planning, wherein pavements outside major fenestration areas, as well as roof areas under clerestory windows are used as planned areas of controlled reflectance in the overall daylighting design.

E. M. LINFORTH:†† We wish to thank the discussors of the paper for their interest and time spent in so doing and to take this opportunity to record our appreciation of their good works, and the works of others, which have provided points of reference and departure for our studies in this field.

The comments of all fall, generally, under one of the several headings below except two which we will discuss separately, first.

We know of no reason to anticipate any significant change in the reflectivity of the aluminum lacquer. The vehicle is an acrylic resin closely related to the plastic of which the panel is made. These materials have proved their durability on prolonged outdoor exposure in architec-

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**Research Engineer, Detroit Steel Products Co., Detroit, Mich.

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††Author.

tural and other such diverse applications as aircraft enclosures, protective coatings for shipboard use, illuminated signs and so forth.

The psychological effect of low transmittance vision strip glazing is a matter which has not been systematically investigated so far as we know. However, there is an increasing number of installations of neutral filter acrylic sheet in school buildings in various parts of the country. We have heard of no adverse psychological effects resulting therefrom. A number of these installations are repeat installations in new buildings by the same authorities. The density of the material is an important factor. The 5 per cent minimum we mention is certainly that and would be required only under extreme conditions of outdoor brightness, such as exposure to a sunlit white stucco wall. Transmittance of 12.5 per cent has been suggested on the basis of studies at the Texas Engineering Experiment Station. We have enjoyed densities ranging from 9 per cent to 25 per cent and have received some adverse comments on the effect of the 9 per cent installation. In general, if the material is neutral and of the proper density in relation to surrounding brightnesses indoors and out, the effect is like good sun glasses — one is unaware of the filter.

Scale

We elected to work at a scale of one-half full size because at this size: (1) the problems of scale to which Mr. Kingsbury refers can be practically eliminated so far as louver panels are concerned, (2) the room is big enough to walk about in which permits meaningful visual appraisal but (3) small enough to permit rotation, adjustment of ceiling height, changing of fenestration, and so forth, by one man. In addition, we believe that data obtained at this scale will provide a basis for correlation with full size of the results of investigations made at smaller scale indoors with controlled sources as Mr. Griffith suggests.

Measurement and Reporting

We sympathize with Mr. Griffith's desire to see all the data. The omission of E_{vg}, except in the section where it is dealt with in detail, was not an oversight but an effort to keep an unavoidably complicated matter as simple as possible for the benefit of those without specialized interest. We also agree that measurement of the direct component is desirable as is the inclusion of E_A (which is now part of our procedure) and sky brightness distribution. One simply has to stop somewhere.

In regard to Mr. Conover's comments on the illumination curves, it seemed desirable to plot them all at the same non-logarithmic scale for easy comparison. It was hoped that indication of minimum values would forestall objection to the resulting smallness.

The ground illumination cell, E_{vg}, receives no light directly from the building wall because it is mounted in a vertical plane facing directly away from the wall in order to measure the incident illumination thereon.

So far we have not studied the problems of louver panel performance vs. slat reflectance nor have we undertaken to extract ground light utilization factors from the data for 45-degree louvers. These are matters which can now be explored most easily at small scale with controlled sources indoors and we agree with Messrs. McKinley and Conover that the information is necessary to a complete understanding of louver panel performance.

Fixed vs. Adjustable Controls

Certainly no one can disagree with Mr. Greene on the variableness of daylight; however, it does not necessarily follow that adjustable controls in the form of venetian blinds provide a satisfactory solution to this problem in all occupancies. If, for example, the objective is to achieve and maintain brightness contrast ratios within the ten to one limit, it would be necessary to set the blind slats to provide a cut-off angle of 0 degrees and leave them that way. Any subsequent adjustment would upset the balance because of the excessive brightness of the sky visible between the slats. Even in areas where limits wider than 10 to 1 are acceptable, venetian blinds leave much to be desired in our opinion. There is almost always a cycling between satisfactory and unsatisfactory performance throughout the day. Louver panels of 0-degree cut-off will provide a relatively stable environment down to a point where there is simply not enough light for the job, which is a situation which can be easily and positively remedied by one simple adjustment — flipping the light switch.

A further advantage of louver panels is their better control of solar heat gain. Recent tests show that 20-degree panels under August 1 conditions of sun and clear sky (standard conditions for cooling load calculations) are approximately 83 per cent more efficient in the reduction of solar heat gain than venetian blinds with the slats set to provide the same cut-off angle (aluminum slats with white baked finish).

Committee Lists in April

The revised listing of the Standing, General, Task and Technical Committees for the year 1955-1956 will appear in the April issue of ILLUMINATING ENGINEERING.

INSTALLATION AT ST. GEORGES R. C. SCHOOL, 843 CLIMAX STREET, PITTSBURGH, PENNSYLVANIA.

Lighting a Visual-Aid Room

LIGHTING OBJECTIVE: To provide various levels of illumination in a visual-aid room for showing movies and slides, and giving demonstrations and lectures.

GENERAL INFORMATION: The visual-aid room shown above is part of a remodeling project which converted an auditorium into a visual-aid room, a small library and six classrooms. It measures 22 feet 6 inches by 56 feet; due to the sloping floor (see Fig. 3) the ceiling height varies from 12 feet at the rear of the room to 14 feet 3 inches just in front of the platform. Surface characteristics are as follows:

ceiling, plaster		
above horizontal panels	white	80% RF
underneath horizontal panels	white	80% RF
walls		
between horizontal panels, acoustic tile	white	78% RF
under horizontal panels, plaster	white	80% RF
dado, linoleum	green	30% RF
floor (auditorium and stage), asphalt tile	tan	20% RF
chairs		
back, wood	black	5% RF
seat, plastic	yellow	25% RF
chalkboard, slate	black	10% RF

(over)

A.I.A. File No. 31

INSTALLATION: Fig. 2 shows the location of all the lighting equipment. The coves are illuminated by 39 fluorescent wiring channels (Pittsburgh Reflector Company), each using one 40-watt T-12 standard cool white rapid start fluorescent lamp, located in rows above the horizontal ceiling panels. Two incandescent luminaires (Pittsburgh Reflector Company catalog No. C-300-5), each using a 300-watt PS-35 clear general service lamp are recessed in the horizontal ceiling panel over the stage. Eight wall brackets (Moe Light, Inc catalog No. M-442), each using three 60-watt A-19 inside frosted general service lamps (an extra socket was built-in on the job), are mounted on the wall 18 inches below the horizontal ceiling panels.

Illumination measurements are as follows:

all lighting units on	
general illumination	30 ft-c
under spots on platform	110 ft-c
cove lights only	
all cove lights on	20-25 ft-c
only cove toward stage	10-12 ft-c
only cove toward projection booth	10-12 ft-c
wall brackets only	
3 lamps on in each bracket	4 ft-c
1 lamp on in each bracket	less than 1 ft-c

Brightnesses, under full illumination, are as follows:

recessed incandescent luminaire,	
louver at 45°	2200. ft-L
wall bracket, at 30°	950. ft-L
ceiling	
near cove	400. ft-L
between coves	15. ft-L
underneath horizontal panels	6.2 ft-L
walls, 7 feet above floor	
between horizontal panels	19. ft-L
below horizontal panels	21. ft-L
dado	3. ft-L
floor, auditorium	3. ft-L
chairs	
back	0.3 ft-L
seat	8. ft-L
chalkboard	3.9 ft-L

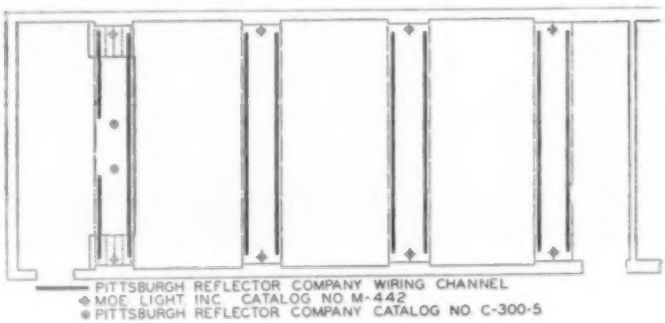
PITTSBURGH REFLECTOR COMPANY WIRING CHANNEL
MOE LIGHT INC CATALOG NO M-442
PITTSBURGH REFLECTOR COMPANY CATALOG NO C-300-5

Figure 2. Plan view showing location of lighting equipment.

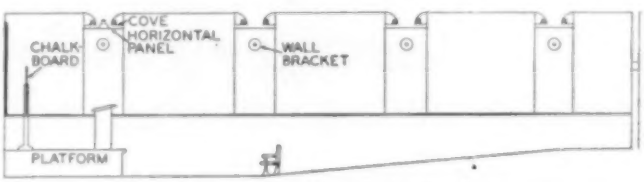

Figure 3. Cross section of visual-aid room.

Lighting designed by William R. Perry, Architect, Pittsburgh, Pa.; Electrical Contractor: Frank Haubelt, 233 Amada St., Pittsburgh, Pa.

Lighting data submitted by Armand Zitelli, Duquesne Light Co., 435 Sixth Ave., Pittsburgh, Pa., as an illustration of good lighting practice and to aid in the design of similar installations.

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Daylighting Design With Overhangs

By J. W. GRIFFITH
W. J. ARNER
E. W. CONOVER

THIS PAPER is a report on the findings of a study of overhang designs carried on by the Daylight Study Project at Southern Methodist University under the sponsorship of the Detroit Steel Products Company and the Libbey-Owens-Ford Glass Company. It presents a method of predicting daylight illumination on the work plane of rooms employing overhangs as a sun control. Values of illumination on vertical walls and ceilings have also been obtained. These may later lead to values which can be used in a method for predicting brightness ratios.

Basic Considerations

There is no limit to the variations in overhang design, but the three basic types are the solid opaque, the louvered or egg crate and the solid translucent overhang. Any of the three types may be horizontal or sloping.

The solid opaque design is the simplest and most common type. It usually extends out horizontally or sloping down from the top of the fenestration area with an under side reflectance the same as that of the ceiling in the adjacent room. This design not only shields against sun and sky brightness, but it is generally used as an outside corridor, thus adding functional area to the building at a low cost.

The louvered or egg crate design is most effective on north or east and west exposures. They are designed to shield the sky brightness and allow the sun and sky light through to increase the ground illumination when the sun is not incident on the vertical plane of the fenestration. They produce higher brightness of the overhang itself by direct and interreflection of sun and sky light on the louvers.

The solid translucent design is not as common as the other types, but it offers the same weather protection as the solid opaque. It also produces increased brightness of the overhang and is very effective when the ground reflectance is quite low.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 12-16, 1955, Cleveland, Ohio. AUTHORS: Engineering Research, Southern Methodist University, Dallas, Texas; Research Department, Libbey-Owens-Ford Glass Company, Toledo, Ohio; and Research Engineer, Detroit Steel Products Company, Detroit, Michigan, respectively.

By sloping the overhang, the same degree of cut-off can be obtained with a narrower overhang. This also reduces the interior illumination from below the horizon.

There is no set rule of thumb that can be used in overhang design. The overhang must be designed for the specific location, orientation, building design and degree of shielding required. Many overhangs are designed for total cut-off of sunlight during hot summer months and only partial cut-off in the winter months when sunlight is desirable. When complete cut-off of sunlight is desired on narrow overhangs, a shade or blind operating up from the bottom of the fenestration is quite effective. If a fixed control is tolerable, a low transmitting glass might also be effective. When the sun is at a low altitude and the entire fenestration area is not needed to produce adequate illumination, the blind is raised to cut-off position. Another effective shielding device is one placed at the edge of the overhang which in effect extends the cut-off range of the overhang when lowered.

Most overhangs continue past the length of the fenestration and where they do not they should be shielded to simulate continuation. This eliminates streaks of light penetrating from the sun at wide azimuth angles.

Light control is not the only functional aspect of overhangs. It is difficult to measure the aesthetic value of overhang designs. However, the reduction of heat load in the summer is considerable. In school design the overhang in conjunction with a concrete walk affords an outside play area during inclement weather. Concrete walks are frequently used under the overhang and as with any high reflecting ground surface it greatly enhances the interior illumination from below the horizon.

Testing Techniques

Due to changing conditions under natural daylight, it is desirable to make illumination readings within rooms as rapidly as possible. Ideally, instantaneous readings at all observation points would be best. To approach instantaneous testing Weston Color Corrected and Cosine Corrected barrier layer cells were located in the surfaces where

the illumination values were to be measured as shown in Fig. 1. The cells on the work plane were at five-foot intervals, on a center line perpendicular to the fenestration, and on a line five feet in from the front wall. The locations on the ceiling and walls were two feet from intersecting planes and on center points as shown. These cell were connected to an instrument panel made up of d-c micro ampere meters with scale readings of zero to twenty micro amps. Each meter was connected through a switching arrangement so that various shunts could be connected across a photo cell thus making it possible to record the electrical response of the photo cells over a range from zero to 750 footcandles. These photo cells were connected to three banks of terminals with twelve pairs of contacts. Each bank of terminals was connected to the twelve meters thus allowing 36 illumination readings to be taken by switching each of the three banks into the meter circuits. The switching arrangement was such that the cells were shorted when not in the metering circuit, thus keeping them activated at all times.

Readings of the meters were taken by photographing the panel with a Polaroid camera. This arrangement permitted a complete test of 36 illumination values to be taken in approximately two minutes. During all tests one of the meters was connected to a cell containing neutral density filters and located in the vertical plane at the outer edge of the model being tested. This permitted correlation of all three banks of reading where variation took place within the two-minute period.

In conjunction with the interior illumination readings, exterior illumination values were measured on the vertical from the sky and the ground combined and also from the sky alone. This was done by placing a large area of black velvet immediately under the exterior photo cell. Brightness

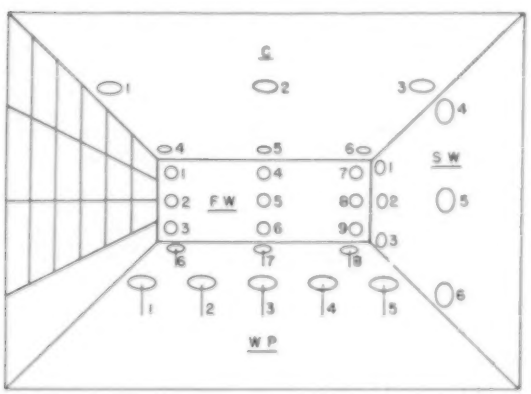


Figure 1. Location of photo cells in test model.

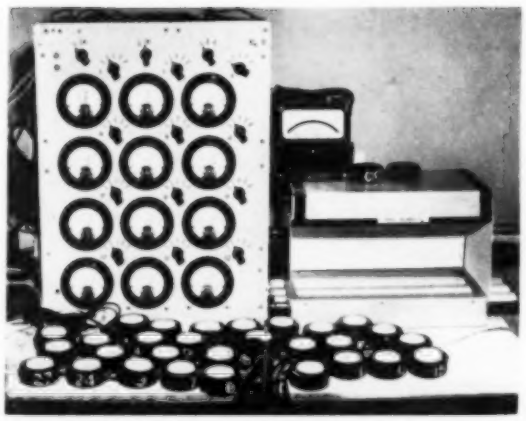


Figure 2. Instrument panel and comparison calibrator.

measurements of the sky vault, the brightness of the ground, and the brightness of a test plate in the horizontal position were also recorded.

At the conclusion of the test each photo cell was placed on the comparison type calibrator shown in Fig. 2 along with the barrier layer cell of a Weston Model 756 illumination meter. The brightness of the flashed opal glass was then varied until a duplicate reading of that shown in each photograph for each cell was obtained. The actual footcandle value was then read from the Model 756 footcandle meter. This technique permitted multiple measurements to be taken simultaneously and have an approximate accuracy to that of the Model 756 illumination meter.

The brightness of the flashed opal glass in the comparator is varied by rotating the fluorescent lamps in the base of the comparator. These lamps have half of the circumference coated first with a white paint and then with a black plastic the entire length of the lamp. The comparator is made of aluminum panels with holes cut in the ends so that three fluorescent lamps can be placed in the bottom of the box. The interior sides of the box are white, and the bottom is black. A piece of flashed opal glass is located two inches from the top panel. Two holes are cut side by side in the center of the top panel so that both the standard cell and the cell to be compared can be exposed to the flashed opal glass at the same time. The accuracy of the readings thus depends upon the accuracy of the standard which is calibrated on the bar photometer.

Brightness readings can be obtained by multiplying the illumination values by the reflectance of the surface where the photo cell is located. This testing technique is also used on tests taken in actual buildings. In this case the photo cells are mounted against the area to be tested.

A similar technique is used for model tests taken under the artificial sky. Since the sky condition is static, it is not necessary to use the photographic recorder but the comparison calibrator has proven to be quite an asset for daily calibration of the photo cells. The model tests taken under the artificial sky and used to develop the prediction technique shown in this paper were taken with $^1/_{12}$ scale models in the daylighting laboratory at Southern Methodist University. The illumination from the sky and the illumination from a uniform ground were taken separately so that the various sky and ground combinations could be predicted.

The illumination from below the horizon was measured in models with and without a shadow under the overhang to obtain the data for Fig. 6.

Performance Data

The illumination values in Table I were taken with the four basic test designs shown in Fig. 3. Section A of Fig. 3 employs a flat solid overhang extending from the top of the fenestration out 12 feet horizontally. Section B employs a horizontal louvered overhang extending from the top of the fenestration out 12 feet horizontally. Section C employs a nine-foot solid overhang extending down from the top of the fenestration at an angle of 15 degrees. Section D employs a 9-foot louvered overhang extending down from the top of the fenestration at an angle of 15 degrees. The solid overhangs were continuous and had an 80 per cent reflectance on the underside. The louvered overhangs were continuous and constructed to simulate a louvered overhang using one-inch by ten-inch lumber with the louvers sloping at 45 degrees to the normal of the overhang. They were spaced to give complete cut-off of light rays incident at 90 degrees and had a reflectance of 70 per cent on the louvers.

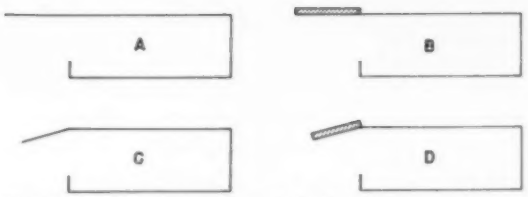


Figure 3. Cross section view of the four basic test rooms.

TABLE I — Illumination Values Taken in a 30′ x 30′ x 12′ test room with floor reflectance of 30%; ceiling (C) reflectance of 80%; a wall (FW&SW) reflectance of 70%; and a 30-inch work plane (WP). Fenestration is clear glass in metal windows extending from wall to wall with a 3′ sill.

Test Cell	1	2	3	4	5	6	7	8	9	10	11	12
WP-1	595	328	337	300	360	572	132	226	91	98	75	91
WP-2	405	235	226	215	241	379	97	159	69	71	57	56
WP-3	269	176	173	146	160	285	67	114	44	44	32	36
WP-4	187	132	127	110	115	166	51	80	33	32	23	26
WP-5	172	130	122	107	110	149	47	68	30	29	21	24
WP-6	588	334	328	293	357	589	140	223	100	107	81	95
WP-7	245	159	154	132	143	223	67	105	41	41	30	36
WP-8	156	123	118	96	100	135	45	62	29	28	19	21
FW-1	572	252	251	204	233	572	135	264	59	66	48	57
FW-2	656	345	347	315	363	632	154	276	87	94	74	86
FW-3	332	169	183	169	202	316	77	131	46	52	46	55
FW-4	189	128	131	107	112	164	64	105	33	34	26	28
FW-5	230	168	164	142	148	209	70	97	38	36	28	29
FW-6	263	197	196	171	179	242	70	96	50	48	40	44
FW-7	147	118	119	88	89	119	47	63	25	26	19	21
FW-8	191	162	155	130	132	166	51	68	33	33	23	26
FW-9	204	172	166	149	148	181	49	66	36	35	27	29
SW-1	186	162	157	103	107	139	62	79	34	34	24	24
SW-2	280	233	227	186	188	228	75	95	48	47	32	38
SW-3	296	252	233	203	201	248	71	92	58	53	39	47
SW-4	234	199	195	122	131	169	69	94	35	35	22	23
SW-5	343	298	295	234	236	290	87	113	54	53	37	42
SW-6	343	297	273	230	235	286	77	105	62	61	45	51
C-1	575	176	183	182	193	607	128	246	39	42	38	41
C-2	151	89	88	78	87	125	45	79	22	23	17	21
C-3	117	93	91	71	73	95	36	47	19	20	15	16
C-4	584	196	209	196	214	600	189	322	43	48	42	46
C-5	154	94	92	77	83	133	48	82	23	24	18	21
C-6	105	84	83	62	67	87	35	46	18	20	14	16

All of the tests were taken with a ground of green grass having a measured reflectance of 12 per cent, except where a walk was placed under the overhang. Tests No. 1 through 6 were taken under a clear east sky with the sun at zero azimuth to the fenestration and at an altitude of 45 degrees. These tests have been adjusted to a total vertical incident illumination of 5300 footcandles at the edge of the overhang with 350 footcandles incident from the ground, 1750 footcandles incident from the sky, and the remainder due to the sun. Test No. 1 was in Section A of the Fig. 3 with a walk extending out 12 feet at the floor level. Test No. 2 was taken in Section A without a walk. Test No. 3 was taken in Section B. Test No. 4 was taken in Section C. Test No. 5 was taken in Section D. Test No. 6 was taken in Section C with a nine-foot walk.

Tests No. 7 and 8 were taken under a clear west sky with the sun at 180 degrees azimuth, behind the model, and at an altitude of 45 degrees. These tests have been adjusted to a vertical incident illumination of 800 footcandles with 500 from the sky and 300 from the ground. Test No. 7 was taken in Section C of Fig. 3 with an 18-foot walk. Test No. 8 was taken in Section D with the 18-foot walk. All walks had a reflectance of 50 per cent.

Tests No. 9 through 12 were taken under an overcast west sky. They have been corrected to a vertical incident illumination of 877 footcandles with 800 from the sky and 77 from the ground. Test No. 9 was taken in Section A, Test No. 10 in Section B, Test No. 11 in Section C, and Test No. 12 in Section D.

All tests have been adjusted to an equivalent base for comparison purposes and no base varies more than five per cent from the average measured illumination for any series of tests.

Prediction Technique

In developing a prediction technique for rooms employing overhangs as a sun control, it was necessary to assume continuous overhangs and complete cut-off of the sun on the fenestration. It seemed advisable to develop a system patterned after the Modified Lumen Method of Daylighting Design[1] and rather than develop a complete new set of curves for predicting daylighting with overhangs the authors incorporated the use of equivalent room sizes so that the curves and general method in their previous paper are applicable to overhang prediction.

To obtain the dimensions of the equivalent room, the width of the overhang is added to that of the room to establish the width of the equivalent room. The length of the equivalent room must be established for each point being predicted. This is done by projecting lines from the point of prediction through the intersections of the front and back wall with the fenestration and out to the edge of the overhang. The distance between the intersections of these lines and the outer edge of the overhang is the length of the equivalent room for that particular point if it does not exceed forty feet. Since the original curves were based on maximum lengths of forty feet, the maximum equivalent length is to be taken as forty feet. The ceiling height of the equivalent room is the same as that of the room under study.

After the equivalent room has been established, the values of illumination from the sky, and from the ground at the maximum, mid-point, and minimum point for the equivalent room are determined by the equation

$$E = \frac{E_i \times A_w \times K \times T_g \times T_w \times M.F.}{D}$$

where

E = Work Plane Illumination from the source, footcandles

E_i = Illumination Incident on the vertical plane, at the edge of the overhang, from the source, footcandles

A_w = Area of masonry opening for window or equivalent, square feet

K = Illumination Coefficient for Sky or Ground

T_g = Transmittance of glazing medium for diffuse incident light (0.8 for clear flat glass)

T_w = Ratio of clear window opening to masonry opening (0.8 for typical metal window construction)

$M.F.$ = Maintenance Factor

D = The perpendicular distance of the point of observation from the outer edge of the overhang, feet

As in the previous paper the room length to room width ratio is determined. The illumination coefficient for each point is read from the sky curves.[1] The curves to determine the illumination coefficients for the ground illumination, Fig. 4 are identical to those in the previous paper; however, the units of the abscissas have been changed. The curves for predicting the Illumination Coefficients of the ground in the previous paper were based on fenestration areas with average sill heights. When the width of the overhang is equal to or greater than the sill height, the sill has little effect on the indirect portion of illumination coming from below the horizon in the equivalent room. Consequently, the area of the fenestration, A_w, is assumed to be the length of the equivalent fenestration times the ceiling height in computing the illumination from below the horizon in the equivalent room.

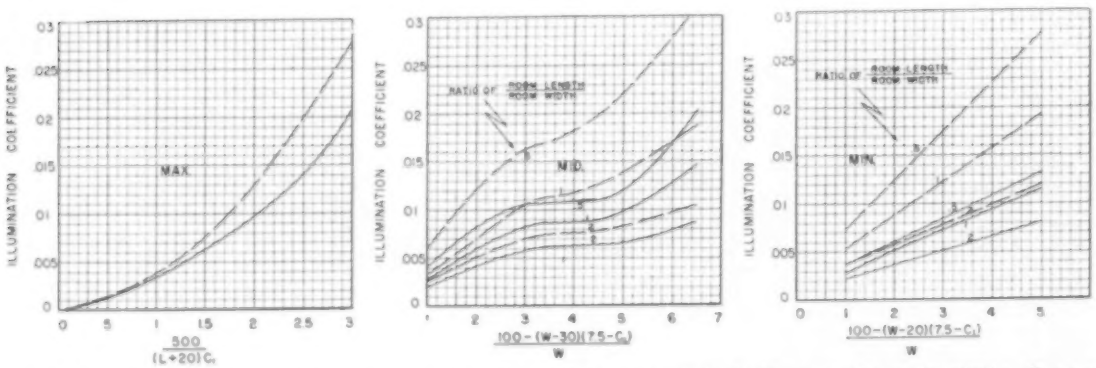
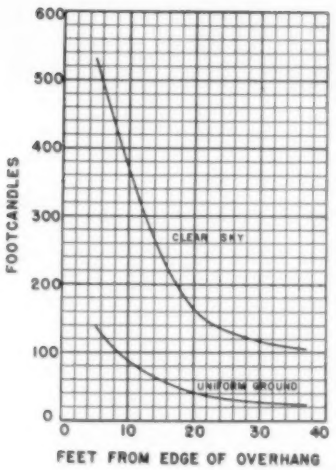


Figure 4. Curves for determining the Illumination Coefficients for light incident on the main window from a uniform ground. Reflection factors: Ceiling 85 per cent, floor 30 per cent, solid curves 30 per cent walls, broken curves 70 per cent walls.



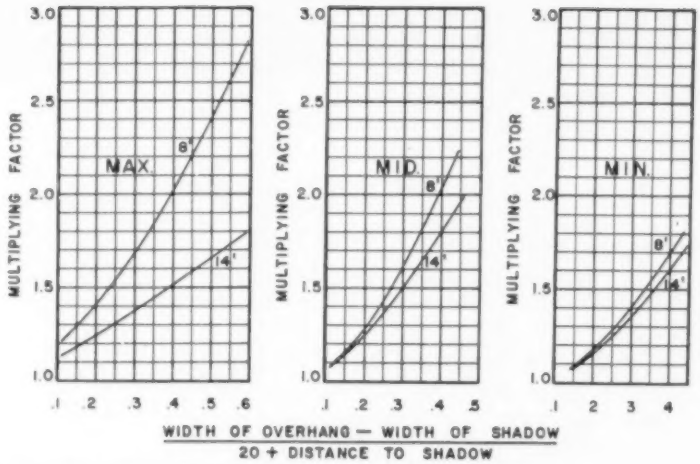


Figure 5. (Left) Footcandle distribution curves.
Figure 6. (Right) Curves to determine the multiplying factors for sunlit areas under the overhang.

The following symbols have been used for simplification:

W = The width of the room in feet measured perpendicular to the window.
L = The length of the fenestration wall.
C = The height of the center of the fenestration above the floor.
C_1 = One-half the ceiling height.

After the illumination values for the equivalent room have been determined, footcandle distribution curves for the illumination from the sky and ground are drawn, Fig. 5. That portion of the curves falling within the limits of the room, excluding the overhang, is the footcandle distribution for the original room employing an overhang control.

Thus far the prediction has been made on the assumption that the shadow of the overhang is equal to the width of the overhang. Where the shadow of the overhang is less than the area of the overhang, the illumination from below the horizon will be considerably more due to the added brightness directly beneath the overhang. To obtain this added illumination from below the horizon it is necessary to multiply the maximum, mid-point, and minimum point values of illumination from the ground by factors obtained from Fig. 6. These multiplying factors vary directly with the illuminated area under the overhang and inversely with the distance of the observation point to the edge of the shadow plus twenty. Curves are given for ceiling heights of 8 and 14 feet. Straight line interpolation may be used to obtain multiplying factors for ceiling heights in between these.

To obtain the total illumination at the maximum, mid-point, and minimum point, the illumination values from the footcandle distribution curve for the sky are added to those from the ground after application of the multiplying factors.

Example:

Predict the illumination values for the conditions given in test #2 in Table #1.

Step 1

Determine the equivalent room size. The equivalent width is 30 + 12 and the equivalent length for all three points is 40. Thus the equivalent room size is 40′ × 42′ × 12′.

Step 2

Determine the variables.

$L = 40$
$W = 42$
$C = 7.5$
$C_1 = 6$

$L/W = .95$ $\qquad \dfrac{14 - C}{L} = .1625$

$$\frac{500}{(L + 20)\, C_1} = 1.389$$

$$\frac{100 - (W - 30)\,(7.5 - C_1)}{W} = 1.95$$

$$\frac{100 - (W - 20)\,(7.5 - C_1)}{W} = 1.6$$

Step 3

Determine the Coefficients of Utilization.

K_s max.	= .0066	from figure 1[1]
K_s mid.	= .0078	from figure 4[1]
K_s min.	= .0095	from figure 7[1]
K_g max.	= .0065	from figure 4 max.
K_g mid.	= .0074	from figure 4 mid.
K_g min.	= .0078	from figure 4 min.

Step 4

Determine the illumination at the maximum, mid, and minimum points from the clear sky alone using the equation.

$$E_s = \frac{E_{is} \times A_w \times K_g \times T_g \times T_w \times M.F.}{D}$$

(a) $E_s$max. $= \frac{1750 \times 9 \times 40 \times .0066 \times .8 \times .8 \times 1}{5} = 532$

(b) $E_s$mid. $= \frac{1750 \times 9 \times 40 \times .0078 \times .8 \times .8 \times 1}{21} = 150$

(c) $E_s$min. $= \frac{1750 \times 9 \times 40 \times .0095 \times .8 \times .8 \times 1}{37} = 104$

Step 5

Determine the illumination at the maximum, mid, and minimum points from the ground alone with:

$$E_g = \frac{E_{ig} \times A_w \times K_g \times T_g \times T_w \times M.F.}{D}$$

(a) $E_g$max. $= \frac{350 \times 40 \times 12 \times .0065 \times .8 \times .8 \times 1}{5} = 140$

(b) $E_g$mid. $= \frac{350 \times 40 \times 12 \times .0074 \times .8 \times .8 \times 1}{21} = 38$

(c) $E_g$min. $= \frac{350 \times 40 \times 12 \times .0078 \times .8 \times .8 \times 1}{37} = 23$

Step 6

Plot a footcandle distribution curve of the equivalent room for the illumination from the sky and from the ground. Fig. 5.

Step 7

Determine the maximum and mid-point illumination for the original room from the footcandle distribution curves.

$E_s$max. = 205 $E_s$mid. = 125 $E_s$min. = 104

$E_g$max. = 50 $E_g$mid. = 29 $E_g$min. = 23

Step 8

Since the area under the overhang is illuminated by the sun, determine for each point the variable:

$$\frac{\text{Width of Overhang} - \text{Width of Shadow}}{\text{Distance of point from shadow} + 20}$$

Max. = .480

Mid. = .343

Min. = .267

Step 9

Determine the multiplying factors from Fig. 6.

Max. *X.F.* = 1.89

Mid. *X.F.* = 1.68

Min. *X.F.* = 1.3

Step 10

Determine the total maximum, mid, and minimum illumination from the ground:

$E_g$max. = 50 × 1.89 = 95

$E_g$mid. = 29 × 1.68 = 49

$E_g$min. = 23 × 1.3 = 30

Step 11

Determine the total illumination at each point by adding the illumination from the sky and the ground.

		Predicted	Measured
E max.	= 205 + 95 =	300	328
E mid.	= 125 + 49 =	174	176
E min.	= 104 + 30 =	134	130

Similar predictions made for the conditions of tests No. 1 and 9 gave the following results.

	Test 1		Test 9	
	Prediction	Measure	Prediction	Measure
E max.	520	595	89	91
E mid.	247	269	45	44
E min.	179	172	33	30

Conclusions

1. Under most conditions the solid horizontal overhang is the more utilitarian type of design. It costs less originally, has a lower maintenance cost, and affords better protection against the weather. It produces approximately the same interior illumination for sun incident on the vertical plane of the fenestration as does the louvered overhang, with less overhang brightness.

2. When the overhang is not used as an outside corridor, the louvered overhang may prove advantageous for non sun exposures on clear days by reducing the shadow effect on the ground and by increasing brightness of the overhang.

3. The sloping overhang will give the same complete sun cut-off as the horizontal overhang with less width, but lower levels of illumination will result. This is due both to lower utilization of illumination from below the horizon and to greater cut-off of the direct illumination from above the horizon at points in the interior of the room.

4. Higher levels of indirect illumination can be obtained from overhang control by utilizing concrete walks as high ground reflectors.

5. Where overhangs are not designed for complete cut-off of the sun on the fenestration, shades or venetian blinds covering the lower part of the fenestration permit complete cut-off when not desired. They can be removed on overcast days or hot summer days, when the sun altitude permits, for both adequate natural illumination and ventilation.

Reference

1. Griffith, J. W., Arner, W. J., and Conover, E. W.: "A Modified Lumen Method of Daylighting Design," ILLUMINATING ENGINEERING, Vol. L, No. 3 (March 1955).

DISCUSSION

R. W. McKinley:* The accuracy of the results obtained by the illumination prediction method described in this paper seems to be adequate and I hope that the authors will continue their work so that brightness predictions can be made as well.

I think it is important that illuminating engineers be aware of the influence their designs may have on other aspects of building performance. For example, the Texas State Engineering Experiment Station has published reports which indicate that small changes in overhang design can make large changes in the ventilation characteristics of buildings to which they are attached.

I am pleased to see that the photographic recording technique has found another practitioner as I believe its general use will help to speed the collection of practically useful daylighting data. I am surprised that the authors have found it necessary to make such frequent cell calibrations. Our work with hermetically sealed Weston cells in a similar system indicated that they were sufficiently stable to make this tedious work unnecessary.

Page 243 mentions an "equivalent base for comparison purposes" and its variation. I wonder if the authors would clarify this point. It has been fairly common practice to base comparisons on a specific set of design conditions related to orientation, season, time, weather, etc. I believe there is need for agreement on such "comparison conditions" among the investigators and designers.

Howard Kingsbury:** I particularly would like to congratulate the authors on having reduced to a rational basis the prediction of daylight in rooms protected from direct sun by large overhangs. It is also interesting to me personally to see an extension and variation of a technique of photographing meter panels to assure simultaneous readings of a large number of test positions. With regard to the selection and use of the instruments, there are several questions I would like to ask. What is the accuracy of the meter selected and why the selection range of 0-20 ma? Unless care is used in shunting such low range meters, my experience has been that response to small changes in exterior light is rather slow. In the use of neutral density filters in the exterior cell, was the arrangement of the filter such that the cosine-corrected characteristics of the cell were preserved? Lastly, in checking through the sample calculations at the conclusion of this paper, I had some difficulty in reading the graphs to the indicated number of decimal places, and I question the use of so many significant figures. If we are to read these graphs to such accuracy, it would seem to indicate that an expansion of them is required.

Bernard F. Greene:† The authors have again presented a most worthwhile contribution in the daylighting field. The subject of overhangs is of particular interest because of the scarcity of technical data on this subject, as well as the widespread usage of overhangs. In the engineering application of overhangs, two of the factors which we do like to consider are the lighting, and the shading of the sun and sky, and from the point of view of its effect on heating and cooling. With regard to the lighting application, it has been our experience, because of the low angles of the morning and the afternoon sun, particularly at the more northern latitudes, it appears impractical to design an overhang which would satisfy the problem of the control of the brightness of the sun. However, from the heating point of view, because of the geometry of the problem, it is practical to use an overhang to reduce the solar heat load. This is particularly important when we start considering air conditioning of a building. This then brings the problem of the design of overhang which would satisfy the heating problem and more clearly reduce the daylight within the room. This can be done by sloping the overhang upward, rather than downward as it is indicated in some of the pictures. Another way would be to mount the overhang projection above the head of the window, in some cases two or three feet above the head of the window. It appears that the advantage of this procedure is that the direct solar radiation can still be reduced and at the same time the daylighting distribution in the back of the room will not be affected. It would be most interesting if an extension of the work of the authors on the subject of overhangs could be completed to include these various factors.

Eric Pawley:* I have gathered from the discussions of the A.I.A. Committee on School Buildings that the question of the use of the overhang has been examined very thoroughly in California schools. Proper utilization of ground reflections has proved extremely beneficial to the lighting of classrooms and this bounce-light on the underside of the overhang has proved very important to total illumination of the room. For that reason I rather suspect that it would be better to keep overhangs and the head of the window at ceiling height for that type of cross-section.

W. H. Kahler:** It is certainly interesting to hear about the work the daylighting people are doing to help the architect and engineer. The new engineering data being made available on the illumination aspects of building components is very useful to the illuminating engineer.

I think the overhang is a very useful device in today's modern architecture. In addition to being a good sun shade for heat and light, it serves as a decorative element to a functional building. The authors state that the solid overhangs had a reflectance of 80 per cent, and at lower reflectance we would expect reduced illumination in the room. I feel that light tints could be used on the under side of overhangs if some color is desired, but this surface should be kept fairly high in reflectance to minimize brightness difference against the sky background. The facing board on the overhang, however, can be finished in any desired color to complete the exterior decorative scheme and the reflectance from this surface will not influence the illumination.

The overhang is also useful after dark because it is a convenient location for recessed luminaires for lighting the exterior of the building, walks and shrubbery.

R. L. Biesele, Jr.:† This paper is a useful extension of the Lumen Method of Daylighting Design, and is the first serious extension of this method of systems incorporating daylighting control media in addition to the clear glass fenestration. It is to be hoped that the authors can continue the extension of this design method to other daylighting controls. The paper by E. M. Linforth (to be published) presented at this same session would indicate

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**Westinghouse Electric Corp., Cleveland, Ohio.
†The University of Oklahoma, Norman, Okla.

that such an extension to fixed louver controls should be quite practical.

There appears to be no reason, technically, why the method cannot be extended to such controls as the shading screens, venetian blinds, and light directing glass block, as well as to the fixed louver systems. In fact, this might be the time for the Daylighting Committee of the Illuminating Engineering Society to solicit this type of information from the interested companies, so as to place at least this aspect of daylighting design on a sound, universal basis. Such a procedure would then release the time of the various research people working on daylighting problems for an attack on the more difficult, but possibly even more important task of developing a brightness prediction technique for daylighting design.

J. W. GRIFFITH, W. J. ARNER and E. W. CONOVER:* The authors wish to thank the discussors for their interest and comments on this paper.

In answer to Mr. McKinley's and Mr. Kingsbury's comments on instrumentation; we would like to state that since most of the field readings are taken on only a few of the possible scales, it is simpler to calibrate at the exact reading with the comparison type calibrator rather than run complete comparison tables on all the possible scales. Actually the cells have been found to be quite stable and periodic calibrations would be sufficient. The d-c microameters used in the recording panel are Weston Model 301 low resistent instruments. The accuracy of these instruments depends upon the accuracy of the comparison calibrator and not their accuracy to measure microamperes. The 0 to 20 range meters were selected in preference to a larger scale so that small changes in illumination values could be recorded more accurately. The metering is such that the response is unchanged by the shunts. The neutral density filters in the exterior cells are placed under the cosine corrector so that the cell is the same with or without the filters. The graphs used for sample calculations were expanded graphs and could be read more accurately than the reproduced graphs in the paper, however, the accuracy in the sample calculations is not required for normal predictions.

The equivalent base for comparison purposes referred to in the paper is an average of the actual incident illumination values for each group of tests. Complete exterior data is given so that the tests can be adjusted to any base for comparisons.

Mr. Pawley's comment answers Mr. Greene's question regarding overhangs above the top of the fenestration. It is possible to simulate the conditions Mr. Greene suggests by using a narrow overhang having the same sun cut-off.

It is quite permissible and probably desirable to use colors of high reflectances wherever possible for illumination designs as pointed out by Mr. Kahler. The overhang lends itself well to artificial illumination and provides another area for indirect illumination as well as recessed luminaires.

As to the continuation of this prediction technique, we are working on incorporation of venetian blind predictions at the present time and hope to have material ready to present at the next conference. We are of the opinion that this type of technique can also be applied to the other areas of the room for prediction of brightness.

*Authors.

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Luminous Cove and Soffit In a Small Kitchen

LIGHTING OBJECTIVE: To provide recommended levels of lighting on the work surfaces and to make this very small U-shaped kitchen look as spacious as possible.

GENERAL INFORMATION: The principal feature of this kitchen is its compactness. It covers just half of the 10-foot by 17-foot kitchen-dinette, the work counter and upper cabinets (at the right in the above photograph) serving as the room divider. The ceiling is 8 feet high. The color scheme was kept in neutral buff and tan to make it appear more spacious and the ceiling (60 per cent reflectance), walls (68 per cent reflectance), rubber tile floor (42 per cent reflectance), and laminated plastic counter tops (55 per cent reflectance) are all in these tones. The tile walls around the sink are yellow (65 per cent reflectance). The cabinets are of natural wood (40 per cent reflectance).

(over)

A.I.A. File No. 31

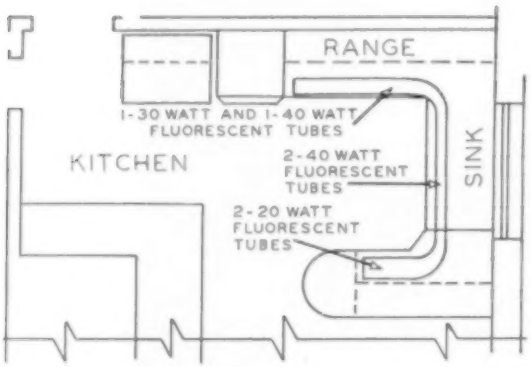

Figure 2. Plan view of kitchen.

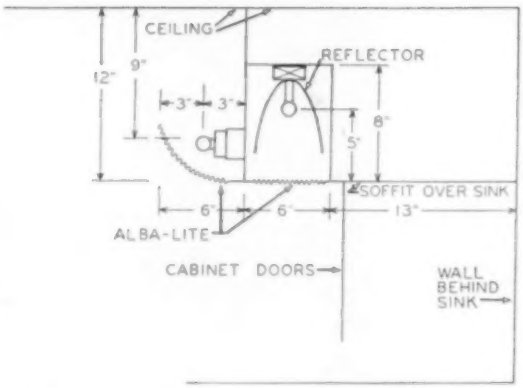

Figure 3. Cross section detail of cove and soffit.

INSTALLATION: As shown in Fig. 2 the lighting, carried as a continuous unit on three sides of the kitchen, is a combination of a luminous soffit and a luminous cove. Built into the soffit recess are one 20-watt T-12 on a trigger start ballast and two 40-watt T-12 rapid start fluorescent lamps. The recessed soffit unit is manufactured by the Compco Corporation and the lamps are positioned 5 inches above the Alba-Lite glass bottom as shown in Fig. 3. The cove part of this installation incorporates one 20-watt T-12 on a trigger start ballast, one 30-watt T-12 standard preheat and one 40-watt T-12 rapid start fluorescent lamp. The "Cove-Lite" is manufactured by Globe Lighting Products, Inc. (catalog No. KG-130-20, KG-130-30 and KG-130-40), and the lamps are located 3 inches out from the wall and 9 inches below the ceiling as shown in Fig. 3. All of the lamps used in the cove and soffit are deluxe warm white. The entire soffit and cove installation is controlled by one wall switch to assure adequate lighting everywhere. There is also a 100-watt A-21 inside-frosted general service lamp in the range hood.

Illumination measurements, taken after over 100 hours of operation, were as follows:

average on range	57 ft-c
average at sink	50 ft-c
work area, right of sink	30-70 ft-c

Surface brightnesses, taken from standing position in the center of the room, were as follows:

cove	590 ft-L
bottom of soffit	270 ft-L

Architect: A. J. DelBianco, 5501 West Irving Park Blvd., Chicago, Ill.; builder: Co-operative Home Builders, Inc., 228 North LaSalle St., Chicago, Ill.

Lighting data submitted by L. C. Bieger, Home Building Representative, Public Service Co., Division of Commonwealth Edison Co., 1701 South First Ave., Maywood, Ill., as an illustration of good lighting practice and to aid in the design of similar installations.

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Footcandles for the Forgotten Man

By SYLVESTER K. GUTH
A. A. EASTMAN

THE PRIMARY objective of the illuminating engineer is to provide a lighting system which will enable a worker to perform his visual tasks efficiently, safely and comfortably. Countless researches involving many criteria have been devised and conducted to obtain fundamental data upon which the specification of light and lighting could be based. While it is generally known, few people think much about the fact that the results of most of these investigations are presented in terms of averages. Thus, we have considerable information concerning the influence of illumination upon the *average* rate of reading, *average* accuracy of performance, *average* visual acuity, *average* discrimination of brightness, etc. Standard deviations, probable errors and other statistical measures often are presented to illustrate the significance and reliability of the data.

Averaged data serve a very useful purpose by providing information regarding the relationships among the various factors involved in light, vision and seeing. The average visual performance of a group of observers with a given level of illumination may be compared with the average performance of the same group with another level of illumination. Little or no attention may be paid to the responses of individual observers other than to use them for emphasizing the reliability or unreli- reduced visual performance by many observers ability of the averaged data. However, in studying the effects of illumination upon performance, it would seem that the responses of the individual observers should be at least of equal, and perhaps of greater importance than the average response. When the data are expressed in terms of, for example, average footcandles to obtain a given performance level, it should be obvious that only 50 per cent of the individual observers will be able to achieve at least the desired level of performance. The question arises whether or not the differences between the individual averages and the group average are so significant as to produce a greatly when they are provided with the average footcandle level. In other words, data need to be obtained and presented in such a way that the responses of the *forgotten half* of the observers can be used to predict the level of illumination necessary to enable them to achieve the desired performance level. Only in this way can those individuals who need it most be given the seeing conditions they require.

Unfortunately, much of the experimental visual data is obtained with only a few observers. Therefore, it is practically impossible to analyze the data in terms of individual performance. Data with highly trained and experienced observers are invaluable for developing the *relative* effects of and relationships among fundamental factors. However, they do not provide a basis for determining the constants which must be used for establishing the absolute values of the factors for typical seeing situations and for typical people.

In a recent study of brightness and comfort,[1] it was emphasized that differences among individual observers are important. A brightness which is comfortable for one person may be extremely uncomfortable for another. This has been recognized and is being used for rating the comfort of lighting systems.[2] It seems entirely logical that the effectiveness of illumination — or task brightness — should be appraised on a similar basis in order to give all individuals an equal opportunity for seeing.

During the past two decades we have obtained extensive data on the relationships between illumination and visibility for a large variety of visual tasks. These data were taken with the Luckiesh-Moss Visibility Meter.[3] In general, they have been adjusted to the "average normal observer" by means of a personal correction factor[4] in order to minimize individual differences. This has been extremely useful for comparing data on a relative basis. By means of "footcandles for equal visibility" the relative amounts of illumination required for various visual tasks may be compared. It also has been shown that evaluations of visibility are related to the absolute threshold footcandle level[5] and to the brightness difference criterion.[6] However, these techniques are inadequate for predicting anything more than the visual performance obtainable by only half of a group of observers.

Weston[7] has stated that for an equal performance of fine work "the illumination required by

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different individuals in an unselected group may range between extremes which are in a ratio of the order of 100 to 1." In our present study, for a comparatively easy task we found a variation in illumination of about 10 to 1. Such ranges should be indicative of the importance of considering the "forgotten half" of workers when footcandle recommendations are being developed.

Visibility measurements were made with the L-M visibility meter by 40 observers. Of this group, 32 were inexperienced observers, most of whom had never used the instrument. No special selection of observers was made except to exclude those who possessed obvious uncorrected eye defects. Thus, the observers were typical office workers who were visually comfortable, wearing their normal correction if prescribed. Their ages ranged from 18 to 61 years. The task was a well printed sample of 8-point type on white paper and was viewed at a distance of 16 inches. Measurements were made with 10, 20, 40, 80 and 100 footcandles. Care was taken to insure that the surroundings had minimal effect upon the observations.

The experimental data are summarized in Table I in which the observers have been arranged in order of increasing visibility as obtained with the 10-footcandle level. It can be seen that the range in visibility for a specific footcandle level is relatively large. For example, for 10 footcandles it ranges from 2 for observer No. 1 to about 5 for observer No. 40, with an average value of 3.48.

As the level of illumination is increased, the visibility level of the task improves. This occurs for all observers. For most of the observers, plots of individual curves of footcandle level vs. visibility are essentially parallel. An interesting comparison is the footcandle level with which each of several observers will obtain a given visibility level. Using a visibility level of 4.95 as a basis, observer No. 40 required 10 footcandles. Observers No. 25, 10 and 2 needed 20, 40 and 80 footcandles, respectively, to obtain the same visibility level. Such differences are neither unusual nor unexpected and have been encountered by most researchers.

A more significant evaluation of the data is presented in Table II. The footcandle levels required by each observer to obtain five specific visibility levels have been obtained from curves of their respective observed data. Thus, for a visibility level of 5, the illumination requirements range from 10 to 88, with an average value of 32 foot-

TABLE I — Visibility Levels Obtained by 40 Observers with 5 Levels of Illumination When Viewing a Sample of 8-point Type at a Distance of 16 Inches.

Observer	Footcandles				
Number	10	20	40	80	100
1	2.00	2.55	3.4	4.8	5.4
2	2.20	2.75	3.6	5.0	5.8
3	2.25	2.85	3.8	5.3	6.1
4	2.30	3.00	4.1	6.0	7.0
5	2.30	3.00	4.4	6.6	7.5
6	2.33	2.80	3.6	4.8	5.4
7	2.35	3.15	4.4	6.8	7.9
8	2.55	3.15	4.1	5.7	6.4
9	2.60	3.50	4.9	6.9	7.7
10	2.80	3.70	5.0	6.6	7.3
11	2.90	4.25	6.3	9.7	11.3
12	3.00	3.95	5.5	7.9	8.9
13	3.10	4.00	5.3	7.2	8.0
14	3.10	4.05	5.8	8.9	10.5
15	3.15	4.05	5.3	7.1	7.9
16	3.15	4.20	5.8	8.5	9.6
17	3.20	4.05	5.4	7.8	8.5
18	3.25	4.30	6.1	9.5	11.2
19	3.35	4.35	5.8	8.0	8.9
20	3.40	4.50	6.4	9.9	11.7
21	3.50	4.65	6.3	8.8	9.8
22	3.54	4.80	6.8	10.0	11.5
23	3.55	4.70	6.5	9.2	10.5
24	3.55	4.90	7.1	10.5	13.0
25	3.60	4.95	7.4	12.0	14.3
26	3.60	5.35	8.2	13.2	15.5
27	3.65	5.05	7.3	11.0	12.5
28	3.70	4.85	6.5	8.7	9.5
29	3.80	5.10	7.7	13.8	18.0
30	3.90	5.35	7.5	11.3	13.0
31	3.95	5.50	8.2	14.5	19.0
32	4.00	5.45	7.7	11.2	12.8
33	4.00	5.45	8.0	13.5	15.3
34	4.40	6.00	8.8	14.5	17.5
35	4.55	6.70	9.9	15.5	18.0
36	4.75	6.90	10.7	18.0	21.5
37	4.90	6.60	9.0	12.5	14.0
38	4.90	6.80	9.9	14.7	16.8
39	4.95	7.30	11.3	18.8	22.5
40	4.95	7.60	12.5	21.0	25.0
Average	3.48	4.72	6.7	10.2	11.9

TABLE II — Footcandles Required by Each of 40 Observers to Obtain Various Visibility Levels When Viewing a Sample of 8-point Type at a Distance of 16 Inches.

Observer	Visibility Level				
Number	3	4	5	7	10
1	30.0	56	88	155	275
2	25.0	49	77	145	260
3	23.0	46	71	125	210
4	20.0	38	58	100	170
5	20.0	33	50	89	160
6	25.0	53	86	160	275
7	18.0	33	48	83	140
8	17.5	38	62	120	215
9	14.0	26	42	83	165
10	12.0	24	41	93	195
11	10.5	18	27	47	83
12	10.0	20	37	64	120
13	8.3	20	35	75	165
14	9.0	19	30	55	94
15	8.6	20	35	77	170
16	9.0	18	30	57	110
17	8.0	20	34	69	130
18	8.0	17	28	50	86
19	7.4	16	28	60	130
20	7.2	16	25	46	80
21	6.8	14	23	49	105
22	6.6	14	22	42	79
23	6.3	14	23	47	93
24	6.8	13	21	39	73
25	6.4	13	20	37	63
26	7.1	12	18	31	53
27	6.1	12	20	37	69
28	5.8	12	22	48	115
29	4.8	11	20	35	57
30	4.5	10	18	35	66
31	5.3	10	17	31	53
32	4.8	10	17	33	65
33	4.3	10	17	32	56
34	3.1	8	14	27	48
35	4.2	8	13	22	40
36	3.6	7	11	20	36
37	2.7	6	11	23	50
38	3.0	6	10	21	41
39	2.9	6	10	19	33
40	4.1	7	10	18	30
Average	9.8	20	32	60	111

candles. It is obvious that observer No. 1 can obtain only a relatively low visibility level with this average illumination. In fact, his data indicate that the visibility of the specific task used in this investigation with 30 footcandles will be 3. Even though there are considerable differences among the observers and in the visibility level each obtains with a given illumination, the relative effectiveness of higher footcandles is about the same. Starting with a visibility level of 4, about a 50 per cent increase in illumination is required for a visibility level of 5 and a three-fold increase will raise the visibility level to 7. With relatively minor variations, this holds true for all 40 observers. It is particularly significant that the averages of Table II are practically the same as the values obtained in the original calibration of the L-M visibility meter when the differences in viewing distance are taken into account.

The visibility levels can be converted into equivalent type sizes.[8] If 30 footcandles on the 8-point type and a visibility level of 5 are taken as the basis of comparison, visibility levels of 4, 3 and 2 correspond to equivalent type sizes of 6, 4 and 2 points respectively. In other words, on this basis, a visibility level of 3 indicates that even with 30 footcandles, it is as though observer No. 1 were reading 4-point type. Certainly, it is a much more difficult task for him than for the other observers.

The reduced visibility levels also can be converted into effective decreased contrasts.[9] Thus, if a visibility level of 5 is obtained with a 95 per cent contrast test object with a specific footcandle level, then visibility levels of 4, 3 and 2, with the same footcandle level correspond to contrasts of 80, 55 and 30 per cent, respectively. Such conversions serve to illustrate the significance of the less than average visibility levels obtained by half of the observers.

The footcandle levels required for various percentages of observers to obtain various visibility levels are plotted in Fig. 1. These values were derived from Table II by arranging the observers into seven groups. The percentages have been plotted on a normal probability integral scale. Since the plotted points may be represented by a series of straight lines, normal or Gaussian distributions of the individual footcandle levels are indicated. Thus, the group of 40 observers can be considered representative of a much larger group.

The relationships of Fig. 1 represent the percentage of observers who will obtain at least a given visibility level with various footcandle levels. Thus, a visibility level of 5 is obtained by 95, 50 and 5 per cent of the observers with 85, 30 and 11

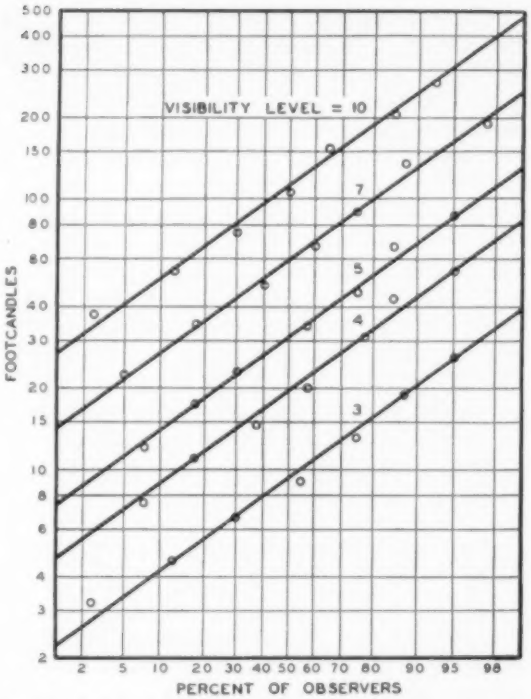

Figure 1. The footcandles necessary for various percentages of observers to obtain given visibility levels.

footcandles, respectively. These relationships emphasize the importance of considering individual subjective variations when determining required levels of illumination. About three times the average footcandle level is required so that 95 per cent of the observers will be able to achieve the visibility level indicated by the average.

Another interpretation can be made from Fig. 1. For example, 20 footcandles providing an average visibility level of 4 may be considered for a specific visual task. However, only 50 per cent of the workers will be expected to obtain at least the average or expected visibility level. About 25 per cent will obtain a visibility level of 5 or more, but 10 per cent will have a visibility level of 3 or less. If this task is a particularly critical operation in a factory, and errors may be costly, it is evident that a higher footcandle level will enable more of the workers to achieve a greater certainty of seeing. Furthermore, it must be remembered that many work-world tasks are considerably lower in visibility than the 8-point type used in this study. Therefore, much higher footcandle levels are necessary to obtain even moderate visibility levels.

The need for relatively large groups of typical observers is further emphasized by Table II. For example, if only the first or last ten observers had been included in the test, the average illumination

levels for a visibility level of 4 would have been about 40 and 8 footcandles, respectively. Similarly, other small groups could require considerably different footcandle levels. Thus, there would be considerable disagreement as to the true average illumination required for a given visibility level. However, the effectiveness of increased footcandles is the same for both groups. That is, to increase the visibility from 3 to 4, the illumination must be approximately doubled. In other words, even though absolute values of illumination are considerably different, the same relative increase in footcandle level is required for a given improvement in visibility.

It is important to point out that the differences in average footcandles required for increased visibility levels are highly significant. This is because of the size of the group used in the investigation. For example, the difference between 20 and 32 footcandles for visibility levels of 4 and 5, respectively, is highly significant at the one per cent level. On the other hand, 10 observers, including the same range as that of the entire group, could be selected whose averages were the same as the group averages for visibility levels of 4 and 5. In this case, the difference would not be significant even at the five per cent level.

Tables I and II illustrate that differences among individual observers are great. Data for a representative observer are presented in Tables III and IV. Visibility measurements were made by observer No. 14 on ten different days. Each datum represents the average of a series of ten individual observations. This was one of the inexperienced observers and the observations of the first day only were included in Table I. The day-to-day variability of a single observer is considerably less than was found among the entire group of 40 observers. Furthermore, there is no indication of a learning trend. This consistency is representative.

TABLE III — Visibility Levels Obtained by a Representative Observer on Ten Different Days.

	Footcandles				
Day	10	20	40	80	100
1	3.10	4.05	5.8	8.9	10.5
2	3.21	4.85	6.1	8.7	10.5
3	3.47	4.72	6.2	8.6	10.4
4	3.33	4.90	6.6	10.0	11.8
5	3.38	4.63	6.3	9.9	12.3
6	3.41	4.63	6.4	9.4	11.7
7	3.30	4.51	5.9	9.7	11.6
8	3.08	3.89	5.2	7.4	8.9
9	3.11	4.18	5.7	8.6	10.3
10	3.31	4.47	5.6	8.7	9.8
Average	3.27	4.48	6.0	9.0	10.8

TABLE IV — Footcandles Required by a Representative Observer to Obtain Various Visibility Levels. Measurements Were Made on Ten Different Days.

	Visibility Level				
Day	3	4	5	7	10
1	9.0	19	30	55	94
2	8.2	17	27	51	93
3	6.8	15	26	50	94
4	8.0	15	23	43	79
5	7.3	15	25	48	80
6	7.3	15	25	48	83
7	8.0	16	25	48	83
8	9.3	22	38	71	115
9	8.9	19	30	57	97
10	7.4	17	29	58	103
Average	8.0	17	28	53	92

The average deviation of the ten-day series of footcandle data in Table IV is about 10 per cent. This compares with an average deviation of about 50 per cent for all the observers (Table II). In other words, the average deviation for the latter would indicate that a relatively large increase in illumination would be required before there would be a significant improvement in visibility for the average observer. On the other hand, the individual data indicate that smaller increases in footcandle level will be significant. It certainly seems worthwhile to consider individual consistency rather than to emphasize inter-observer variability.

While the 40 observers are not uniformly distributed in various age groups, an evaluation of the data does indicate a definite trend towards lowered visibility for the older observers. This is illustrated in Table V. It is evident that these older observers require a higher footcandle level to obtain a given visibility level than do the younger observers. For example, the 46-55 age group needs about 100 footcandles for a visibility level of 8 as compared with 40 footcandles required by the youngest group. Other comparisons indicate that the two oldest groups require from two to three times more illumination than the 16-25 age group for a given visibility level. This is in general agreement with Weston's results for visual performance which involved speed and accuracy.[10]

TABLE V — Visibility Levels Obtained by Various Age Groups of Observers with 5 Levels of Illumination.

Age Group	Number of Observers	Footcandle Levels 10	20	40	80	100
16 - 25	11	3.95	5.6	8.0	12.4	14.6
26 - 35	16	3.43	4.7	6.8	10.3	11.9
36 - 45	6	3.58	4.7	6.5	9.3	10.5
46 - 55	6	2.48	3.2	4.5	7.0	8.4
56 - 65	1	2.30	3.0	4.4	6.6	7.5

A slight degree of subnormal vision is an important factor. Ideally, all eyes should be properly corrected. However, many people cannot be given so-called normal or 20/20 vision. The data of Table VI obtained from a previous investigation, illustrate how the visibility decreases with the visual rating. All the observers wore their prescribed correction. The visibility level obtained with the

TABLE VI—Visibility Levels and Footcandles for Equal Visibility for Observers Possessing Normal and Subnormal Vision.

Visual Rating	Visibility Level (10 Footcandles)	Footcandles for Equal Visibility
20/20	3.57	10
20/25	3.16	14
20/30	2.80	18
20/40	2.15	46

20/20 group is very nearly the same as the average shown in Table I for the 40 observers. The footcandles for equal visibility are particularly significant. Even a slight degree of subnormal vision (20/25) requires a 40 per cent increase in level of illumination. Comparing the data shown in Tables I and VI, it is evident that the low visibility group of the former have, in effect, subnormal vision. Thus, if differences in visual abilities illustrated in Fig. 1 are taken into consideration, levels of illumination can be prescribed which will provide the desired visibility level.

This brief summary illustrates the importance of considering individual ability and performance when developing footcandle recommendations for specific tasks. If all visual responses were identical, it would be a very simple thing to do. The apparent lack of statistical reliability of data should be considered as positive rather than negative information. Averages are useful, but not all informative. If experimental data show that all observers obtain benefits from improved seeing conditions, the differences among them should not be neglected.

It may seem idealistic to specify lighting requirements in terms of individual visual performance. Nevertheless, it is not idealistic to develop a broad concept in which consideration is given to the forgotten half of the workers who cannot attain efficient visual performance with the light and lighting designed for the average person. Obviously, it generally will be uneconomical to provide individualized lighting for all workers. But, everyone will benefit from more nearly adequate footcandle levels. Those who possess a relatively low visual ability can be raised to a reasonable level. At the same time others will be given even better seeing conditions. The mere fact that these higher footcandle levels may be difficult or uneconomical to obtain today should not prevent us from setting them as our goal for the future. Too often the goal of yesterday has become the millstone of today, holding us back from accomplishing what we know should be done. Our ultimate and invariable goal should be the ideal.

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DISCUSSION

H. L. LOGAN:* I am glad to see this paper by Dr. Guth and Mr. Eastman as it gives detailed evidence supporting the view that man's response to light is not precise, but is a range response; and adds to the data accumulated on the other senses which likewise have been demonstrated to give range and not precision responses. This is the reason why precise rules lack validity. Such rules imply a narrowness and degree of conformity in human visual response, among individuals, that is contrary to the mounting evidence.

On the other hand we cannot, as Dr. Guth agrees, go to the extreme of establishing visual fields for individuals; nor can we base our specifications on the limitations of the least-favored individual in a group. It is a matter of economics rather than technology. There is just one fundamental activity in which we can engage, and that is changing the form or relationships of things. This consumes energy. This is true whether the thing created is an electric motor, a ship, a new configuration of thought, or a field of view. Energy is the only form of wealth that humanity can utilize, and as long as what is available to us is limited it must be used with discretion. Also, our knowledge is limited; so for two reasons we have to be satisfied with the approximations we call averages. All our experience shows that we can, so-to-speak, get away with a lot of approximation and still get the result we want, nearly enough for our purpose. This is sound engineering, because, as Mr. Waldram recently pointed out "surely the engineer is the man who knows how, when and where to approximate."

This new data of Dr. Guth's will help the engineer to approximate with improved judgment in the future.

G. A. FRY:** It is certainly important to have attention called to this particular problem. The comment that I want to offer relates to the cause of variability from subject to subject. I notice that in the selection of these subjects no particular attention was paid to the refractive correction and that the subjects were permitted to wear their normal corrections, if any, and it was simply noted that there were no anomalous subjects in this regard. I notice also that the measurements were made at a distance of 16 inches and the subjects ranged up to 61 years of age. In a sample of any population you are apt to run into people who are having optical difficulties when confronted with this kind of task and I would like to suggest therefore that this is an

*The Holophane Co., New York, N. Y.
**School of Optometry, Ohio State University, Columbus, Ohio.

important variable in this type of study. I don't know from an engineering point of view whether it is important to just deal with a sample of the population, but you can take this approach to it. In other words, in a given factory you are going to have people with this cause of variation and you are going to have to work with them and you can't give people corrections — all you can do is to improve their lighting. Now this information is useful if you approach it from this point of view. But on the other hand, I know that Dr. Luckiesh used to regard professional eye care and lighting as partners in efficient seeing and one should not forget that in a program of this sort that one can provide corrections which will bring people up to a much higher level of efficiency than you run into in a sample of a typical population. I am raising the question of whether our basic data ought to be formulated in terms of people who are quite adequately corrected and then make allowance for the fact that we do run into people in a given population that are not adequately corrected.

DOMINA EBERLE SPENCER:* I am heartily in sympathy with the aim of this paper. It is certainly preferable to attempt to provide an adequate luminous environment for 95 per cent of the occupants or for all of the occupants rather than for the average occupant.

The qualitative conclusions are also probably correct: (1) That many benefits are still to be gained from increasing the quantity of light provided that reasonable helios uniformity is obtained. (2) That an increase in quantity is of more benefit to people with subnormal vision than to people with perfect eyes, though all benefit to some degree if the lighting is properly designed.

However, the paper again raises two old questions. The first is inherent in the use of any visibility meter. Have we any certainty that improvements in vision with improved lighting are actually being measured when we (with much of the field of view blocked by a black instrument) rotate a translucent film in front of our eyes until a standard visual task is reduced to threshold? The second has to do with the treatment of quantity as separate from quality. In providing "footcandles for the forgotten man" we may give him visual benefits or we may curse him with intolerable visual conditions. I would agree that the benefits of improved visual conditions implied in this paper would indeed be benefits if provided with a properly designed luminous ceiling combined with high room reflectances. With such a system, I agree with Eastman and Guth that there will be visual benefits right up to daylight values — despite the fact that this is contradicted by Dr. Guth's blinking comfort analysis. But if applied to the majority of lighting fixtures on the market today, the footcandles for the forgotten man will be converted into headaches for all.

More definitely significant results can be obtained if we base our evaluation of the luminous environment directly on measurements of visual performance. Both quality and quantity of the surround should be considered simultaneously. At no time should the state of adaptation be ignored.

What is needed today is an analytic extension of the basic ideas of the delos method[1] to include a wider range of tasks and a wider range of variables. The suggestions of Blackwell[2] and of Eastman and Guth are in agreement on one point. Instead of taking a 50 per cent criterion, future visual work should employ the entire S-curve as Eastman and Guth have done in Fig. 1. If a satisfactory analytic form for summarizing all of the visual data can be found, it will contain a much larger storehouse of information than has previously been found possible to compress into a single equation.

Do the authors plan to employ the data of the present paper as a weapon for revision of the 30 lumen ft^{-2} recommended for school lighting today? With the slogan "Average vision for 95 per cent of the children," can they convert the current recommendation of 30 lumen ft^{-2} into 90 lumen ft^{-2}? This would be a laudatory result provided firm and adequate restrictions were also incorporated into the report as to the control of non-uniformity of the luminous environment.

1. Moon, Parry, and Spencer, D. E.: *Lighting Design*, Chapter VIII, Addison-Wesley Press, Cambridge, Mass, 1948.
2. Blackwell, H. R.: "Use of Performance Data to Specify Quantity and Quality of Interior Illumination," ILLUMINATING ENGINEERING, Vol. L., No. 6 (June 1955).

SYLVESTER K. GUTH and A. A. EASTMAN:* As we pointed out in our paper, economic factors play a big part in placing limits on the footcandle levels provided for various work-world tasks. However, such factors should not be permitted to hinder us from developing a broader concept upon which lighting practice can be based. What is uneconomical or impractical today may some day in the future be considered very economical and highly practical.

We do not feel, as Mr. Logan seems to, that it is imperative for us "to be satisfied with the approximations we call averages." Progress often results from someone's dissatisfaction and his efforts to do something about it. An individual's response to light usually is fairly consistent. It is when we begin to compare individuals that we obtain an apparent lack of agreement. However, we generally find that most people respond in an orderly and regular manner. For example, the parallelism of the relationship shown in Fig. 1 of our paper illustrates that both the high and low visibility groups obtained equal increases in visibility with equal percentage increases in footcandles. That is, a threefold increase in illumination will improve visibility from 4 to 7 regardless of whether an individual stands high or low in the entire group.

If our analysis had been made of data obtained only by the half of the group having lower visibility levels, the average footcandle levels would have been considerably higher. Nevertheless, a similar parallel relationship would be obtained and result in the same conclusions. In other words, while the actual average may change, relative effects remain about the same.

These comments do not mean complete disagreement with Mr. Logan's viewpoint. He is applying an engineering evaluation to the data. Our hope, along with his, is to minimize approximation and improve judgment.

We agree wholeheartedly with Dr. Fry that professional eye care must be considered as a partner of adequate lighting for efficient and comfortable seeing. Certainly everyone should be encouraged to have properly corrected vision. Our emphasis on the differences in footcandle requirements was to show how the needs of many workers may be overlooked when lighting levels are based on averages.

Our objective was to evaluate the responses of a typical group of observers having so-called normal vision. None of the observers exhibited any apparent visual disability or discomfort. We did exclude a few individuals who had impaired visual ability even with their normally prescribed correction. The differences obtained in this study agree

*University of Connecticut, Storrs, Conn.

*Authors.

with some earlier work in which observers having equal visual acuity indicated a wide range when contrast sensitivity was used as a criterion.

The variables of visual response associated with age are important and were recognized. Our survey with its limited number of observers is in agreement with Dr. Fry's suggestion that the older person is likely to encounter more visual difficulties than the younger person even when he is wearing his "proper" prescription.

Much valuable basic data could indeed be obtained by studying the responses of a large group of observers who were corrected to the maximum. Nevertheless, a perfect retinal image does not necessarily mean that a person will have perfect seeing. It is quite possible that a narrower range of responses would be found with such a group. However, we must not overlook the fact that our observers represented a relatively selected group and that an even wider range of responses probably would be found with a larger population. In view of this, the implications of our present data as to footcandle requirements would seem to be very conservative.

Dr. Spencer appears to be dubious about the visibility meter. We have never pretended it to be the final answer for evaluating perception. However, it does enable us to evaluate or numerically rate suprathreshold situations and to determine footcandles for equal visibility. This is difficult to do with measurements of minimal size or brightness upon which her delos method is based. Unfortunately, we do not have a single criterion that gives us all the answers. Therefore, it is necessary to use all that are available, but always being sure that we understand its meaning and true significance. On this basis, the Luckiesh-Moss Visibility Meter is a useful tool. With it we can fulfill one of Dr. Spencer's suggestions of studying a wider range of tasks.

Obviously, the level of illumination alone, is not the entire answer to any lighting problem. Quality of lighting is recognized as becoming increasingly important with higher footcandle levels. This does not mean that quantity and quality cannot be evaluated separately. Furthermore, studies of visual performance do not tell us very much about overall visual comfort.

We do not intend to use our data as a weapon nor to develop a slogan for raising recommended footcandle levels. Our objective is to continue to provide material for a sound and logical basis for improving lighting practice. Once such a basis is developed there will be few questions regarding the recommendations. We may not be able to achieve the ideal, but a suitable relative scale will tell us how far along the road we are towards it.

Several years ago, a speaker at a vision conference commented that to his way of thinking there were few things as conservative as the footcandle recommendations of today's lighting practice. This man is not directly associated with the lighting industry, but he is familiar with visual research. We feel that a proper and broader evaluation of experimental data will unchain us from narrow unjustifiable conservatism. Our hope is that this paper will be one more step in that direction.

Floodlighting A Church Spire

Floodlighting the spire of the First Presbyterian Church, in Jackson, Miss., was an afterthought, and lighting engineer W. W. Huntley, Mississippi Power and Light Co., had to "make do" — on limited funds — with an existing situation.

The floodlight selected was equipped with clear heat-resisting lens and used a 300-watt 120-volt sealed beam reflector spot lamp with 30-degree beam spread. Two of these units were mounted on a 25-foot 3-inch steel pole near the sidewalk on the north side of the building. On the south side, a place was found on the parapet wall, between the Sunday School room and the Chapel, to install two floodlights, on pipe with bracket. On the west side of the building it was necessary to set a 35-foot wooden pole across the street with three floods mounted on the top.

All floodlighting equipment is controlled by time switch.

Data for Designing Show Window General Lighting With PAR and R Lamps

(Discussion of paper by C. N. Clark, published November 1955 issue of ILLUMINATING ENGINEERING.)

RICHARD KELLY:* I am indeed interested in display window lighting, and have let off a fair amount of steam about it at one time or another. I was delighted to read the opinions from all the extraordinary amount of work Mr. Charles Clark put into his report.

I do not want to comment or criticize any of the detail of the second two-thirds of the report, as that sort of detail is of great importance after the merchandising intention is decided, but less of general planning importance. Not to be confusing in wording, I believe in:

(a) Deciding on the impact desired.

(b) Using every available person of imagination to make the effect.

(c) Applying all of the scientific data available for the effect.

Effect is, of course, the most important thing in selling.

I wholeheartedly agree that the daytime problems are of first importance and I would add I think they are not to be standardized but differ, not only according to orientation but to the surroundings. That is, even though a store in the country may be facing east or south, planting or other accidents of shielding may help it. In the city, ordinarily a store facing east with terrific glare from the west during the major shopping hours has the worst condition.

For example: I have noted that the shops on the east side of Fifth Avenue in New York City are much better off in window lighting than those on the west side for the almost overly apparent reason that very few people shop before the sun happens to change direction here. (Fifth Avenue runs from the lower end at a slightly west of south to the north slightly east of north.) Thus shops and stores on the west side of Fifth Avenue suffer by reflections on light limestone, white marble, etc., and glass of buildings on the east side of Fifth Avenue to the west so that no one can see clearly into these windows until sundown. Naive attempts have been made by use of blinds, etc., which usually only cut the whole of the display in half.

This example will indicate my feeling that a too exact specification of footcandle values, for both general lighting and specific spot lighting, can be regarded as finally true for good selling. Two hundred footcandles general lighting may be desirable for part of the day in certain locations and in other locations less or more. Night lighting can be determined with a great deal more finality than artificial lighting for day. Therefore, I suggest that all daytime lighting recommendations for store window use and the areas of "open front stores" be recommended as subject to the requirements of:

(a) The merchandise and the quality of impact to be made.

(b) The climatic exposure in relation to sun glare, chiefly from reflective areas.

(c) Architectural considerations involved in the institutional character of the store itself.

As to lighting methods: It seems to me there are very few absolute rules as to when to use incandescent lamps and when to use fluorescent lamps, depending entirely upon the city, the part of the city, the suburb, the surroundings, part of the country, north or south, east or west. No rule which doesn't consider all these variables can be very valuable.

I agree with Mr. Clark that all of the wonderful techniques used in stage lighting recently tend in various ways to make more effective display lighting for selling.

*Lighting Designer and Engineer, New York, N. Y.

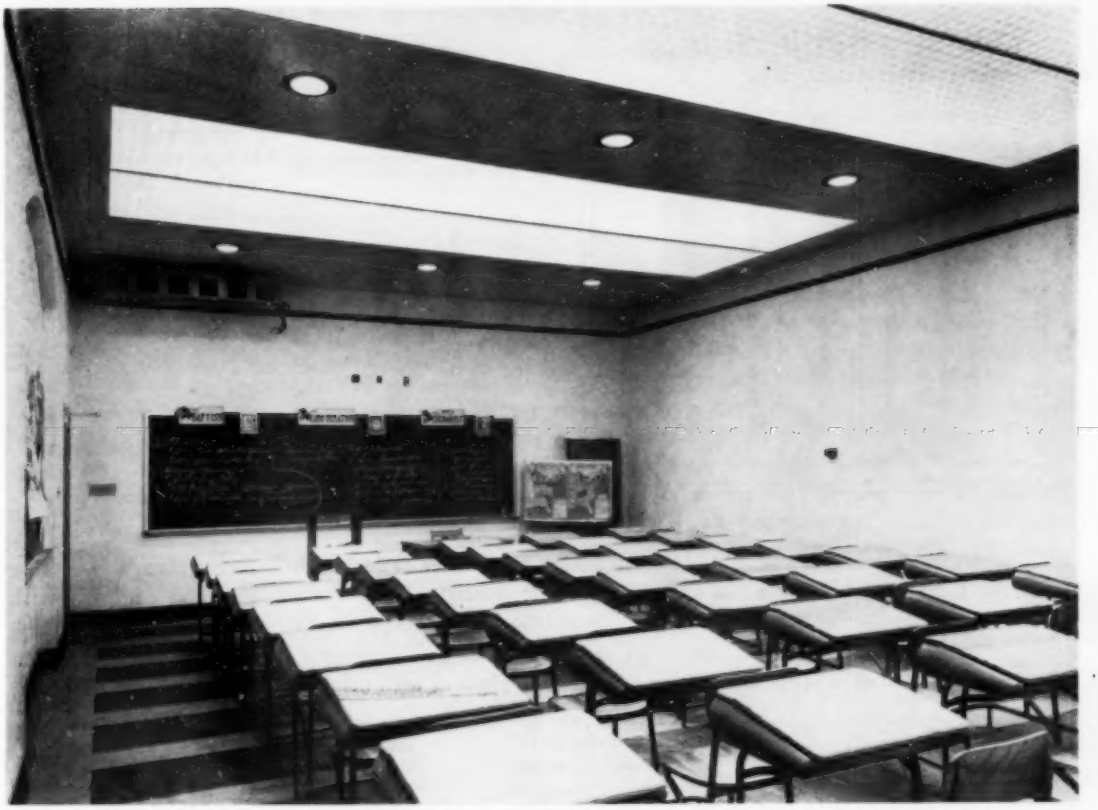
CHARLES N. CLARK:* I certainly agree with Mr. Kelly that from the merchandising standpoint, the effect — the ability to attract attention of passers-by through brightness, contrast, color, motion, etc. — of a show window, is most important. There is, of course, great latitude in the methods of achieving the effect.

A system of general lighting, providing relatively high vertical-surface illumination rather uniformly distributed throughout the window, appears, from observation of both theory and practice, to be an essential lighting component of an effective window. The importance of additional lighting, particularly spotlighting at levels of 1000 to 2000 footcandles, in addition to general lighting, cannot be overemphasized. Such spotlighting is necessary not only to assure visibility of featured items despite reflections, but also to provide the dramatic effects sought by many display people.

I am glad that Mr. Kelly agrees with our estimate of the importance of designing daytime-effective windows, and must agree with him that the severity of the daytime reflection problem will depend upon many factors — orientation, reflectance of surrounds, etc. I did not intend to imply in the paper that 200 footcandles general illumination was the appropriate level for minimizing the veiling effect of reflections from glass under all conditions. However, from thet past studies cited, it appears that 200 footcandles (on light colored surfaces) results in satisfactory reduction of veiling glare for all but the very severe conditions. Since it appeared desirable to base the design procedure on some fixed level of illumination, 200 footcandles was selected as having the widest applicability. Lighting designs for levels other than 200 footcandles can readily be calculated according to Step 6 in the design procedure section.

As indicated in the second paragraph of the paper many windows may require individual study. It is suggested for show windows to be relighted the designer measure the actual reflected brightnesses on the window-glass under the most severe conditions, and design the general lighting so as to provide vertical-surface brightnesses (footcandles × surface reflectance) inside the window that are equal to or greater than the maximum reflected image brightness. This will assure that the viewer can at least partially "see through" the reflections. For new installations where measurements of actual reflections are impractical, estimates can still be made by assuming that the glass will reflect 10 per cent of the brightness of surrounding objects imaged on it.

*Author, General Electric Co., Cleveland, Ohio.



INSTALLATION AT ST. GEORGES R.C. SCHOOL, 843 CLIMAX ST., PITTSBURGH, PA.

Lighting a Windowless Classroom

LIGHTING OBJECTIVE: To provide adequate illumination and a cheerful atmosphere in a windowless classroom.

GENERAL INFORMATION: The classroom shown above is part of a remodeling project which converted an auditorium into six classrooms, one visual-aid room and a small library. It measures 22 feet by 31 feet, ceiling height is 11 feet. Surface characteristics are as follows:

ceiling, acoustic tile	white	80% RF
walls, rough plaster	light pastel green	70% RF
floor, rubber tiles	green tiles	15% RF
	gray tiles	30% RF
	red tiles	10% RF
desk tops, light oak	natural finish	30% RF
chalkboard. glass	green	20% RF
tackboard	tan	20% RF

INSTALLATION: The two louverall sections are formed by eight fluorescent wiring channels (Neo-Ray Products, Inc. catalog No. 502-296) mounted 21 inches above eggcrate louvers (Neo-Ray Products, Inc. catalog No. ML-2448) and spaced as shown in Fig. 2. Each channel uses two 96-inch T-12 standard cool white slimline fluorescent lamps. While there are no windows in the classroom the light from the louverall sections is supplemented by daylight from the screen glass

(over)

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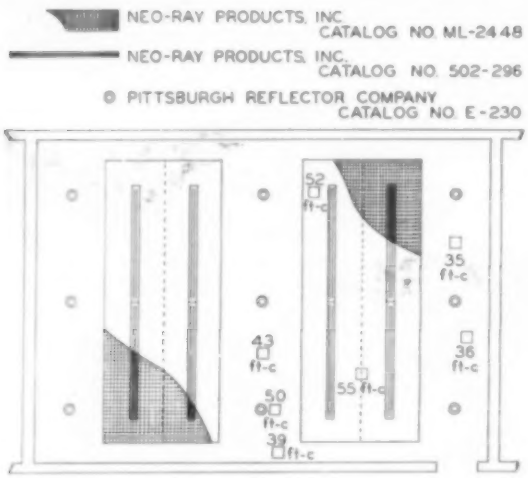

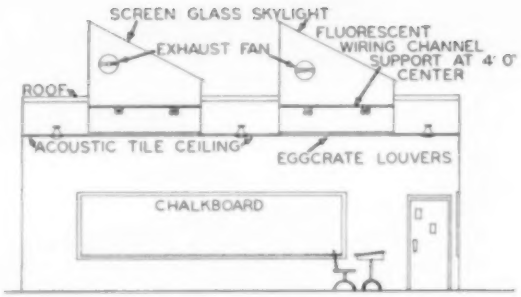

Figure 2. (left) Plan view of classroom showing location of lighting equipment and illumination distribution

Figure 3. (above) Cross-section of classroom.

skylights as shown in Fig. 3. Nine incandescent luminaires (Pittsburgh Reflector Company catalog No. E-230), each using a 300-watt PS-30 inside frosted general service lamp and equipped with HCR-6 glass roundel, are recessed in the ceiling and located at shown in Fig. 2.

Average general illumination, at desk height, is 44 footcandles. Fig. 2 shows illumination levels measured at specific points on a horizontal plane at desk height. Brightnesses are as follows:

Louverall sections	
louver, crosswise at 45°	**70. ft-L**
louver, crosswise at 30°	**60. ft-L**
louver, lengthwise at 30°	60. ft-L
incandescent luminaires	
glass roundel at 45°	**900. ft-L**
ceiling, between luminaires	13. ft-L
side wall above chalkboard	26. ft-L
floor	
green tiles	4.5 ft-L
gray tiles	12. ft-L
red tiles	3.5 ft-L
desk tops	18. ft-L
white paper (80% RF) on desk	40. ft-L
front chalkboard	6.5 ft-L
tackboard	6.3 ft-L

Lighting designed by William R. Perry, Architect, Pittsburgh, Pa. and installed by Frank Haubelt, Electrical Contractor, 233 Amada St., Pittsburgh, Pa.

Lighting data submitted by Armand Zitelli, Duquesne Light Company, 435 Sixth Ave., Pittsburgh, Pa. as an illustration of good lighting practice and to aid in the design of similar installations.

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Fluorescent Luminaires For Refrigerated Areas

By T. SUMMERS, JR.

OWNERS AND operators of cold storage warehouses have long been aware that if fluorescent lamps could be used in refrigerated areas, a saving in operating cost would result not only from the more efficient source but also due to the smaller amount of generated heat. The total refrigerated area concerned in this country alone is several million square feet, and these vast areas must be kept at temperatures of approximately 0°F or lower. With lower operating costs, tremendous savings can be made possible to the cold storage industry.

Information obtained from owners and operators of cold storage areas indicate that two main problems are involved in a lighting installation for refrigerated areas. The two problems are (1) the seeing tasks and (2) the temperature. The seeing task problems can be broken down into two general classifications. These are:

1. Areas where the seeing task is not critical as in dead storage. Here is it only necessary to read large labels on cartons or boxes. Experience has indicated that from 5 to 10 footcandles is adequate for this seeing task. In order to provide this low level of illumination with good uniformity, a single lamp unit is usually desirable.
2. Areas where the seeing task is more critical since it may be necessary to read fine print on packages. For this type of task a level of 25 to 35 footcandles is required. To provide this level of illumination economically, a two-lamp unit is desirable.

The temperatures involved can be broken down into three general ranges. These are:

1. Areas kept at approximately +40°F where goods such as canned milk and chocolate are stored.
2. Areas kept at approximately 0°F where goods are stored for relatively long periods of time.
3. Areas kept at approximately −30 to −45°F for quick freezing or meat freezing.

Areas kept at a temperature of approximately +40°F do not pose any special problem. There are many of these areas in which standard fluorescent lamps have been used with very satisfactory results. As these areas do not present a problem when using conventional equipment, this paper is concerned only with the two other areas (*i.e.*, the 0°F and the −45°F areas).

The two main requirements for luminaires in cold temperature areas are reliable starting and good light output. Not only does the starting of fluorescent lamps become more difficult as the temperature decreases but also the light output is adversely affected.

The purpose of this paper is to report on the results of an investigation made from an actual installation of various lamp, ballast and luminaire combinations under field conditions.

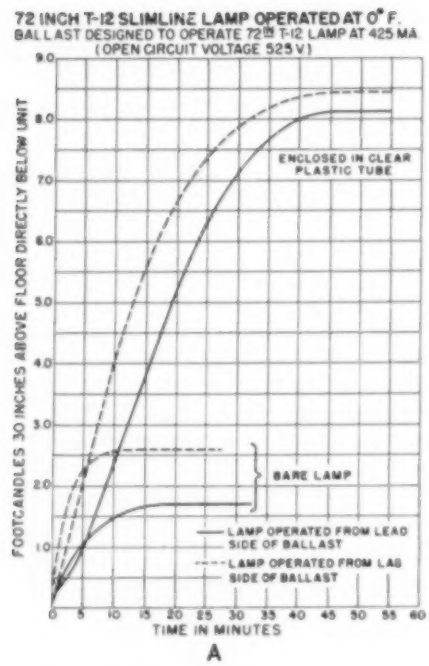
Test Procedure

To determine the most advantageous lamp and ballast combination to achieve the requirement of reliable starting and good light output, arrangements were made with the National Terminals Corporation to install test luminaires in one of their cold storage rooms for the purpose of obtaining preliminary test data. The luminaire and ballast combinations installed for the investigation were as follows:

I. (a) Luminaire—Six-foot single bare lamp unit with ballast for operating 72-inch T-12 slimline fluorescent lamp at 425 ma (525-volt open circuit).
   (b) Lamp—72-inch T-12 fluorescent lamp.
   (c) Combinations tested:
      (1) Bare lamp operating on lag side of ballast.
      (2) Bare lamp operating on lead side of ballast.
      (3) Lamp enclosed in close fitting clear plastic tube and operated on lag side of ballast.
      (4) Lamp enclosed in close fitting clear plastic tube and operated on lead side of ballast.

II. (a) Luminaire — Four-foot single-lamp unit equipped with a diffusing plastic shield and a ballast for operating 72-inch T12 slimline lamp at 425 ma (525-volt open circuit).
   (b) Lamps—48-inch T-12 (both standard and low temperature) fluorescent lamps.
   (c) Combinations tested:

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 12-16, 1955, Cleveland, Ohio. AUTHOR: Westinghouse Electric Corp., Lighting Division, Cleveland, Ohio.


72 INCH T-12 SLIMLINE LAMP OPERATED AT 0° F.
BALLAST DESIGNED TO OPERATE 72" T-12 LAMP AT 425 MA
(OPEN CIRCUIT VOLTAGE 525 V.)
FOOTCANDLES 30 INCHES ABOVE FLOOR DIRECTLY BELOW UNIT
ENCLOSED IN CLEAR PLASTIC TUBE
BARE LAMP
LAMP OPERATED FROM LEAD SIDE OF BALLAST
LAMP OPERATED FROM LAG SIDE OF BALLAST
TIME IN MINUTES
A

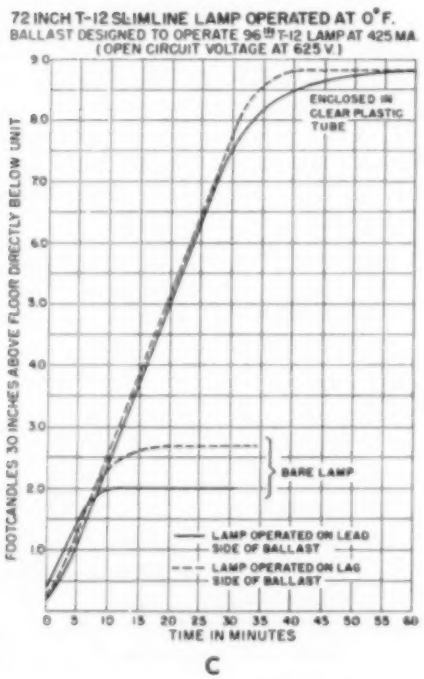
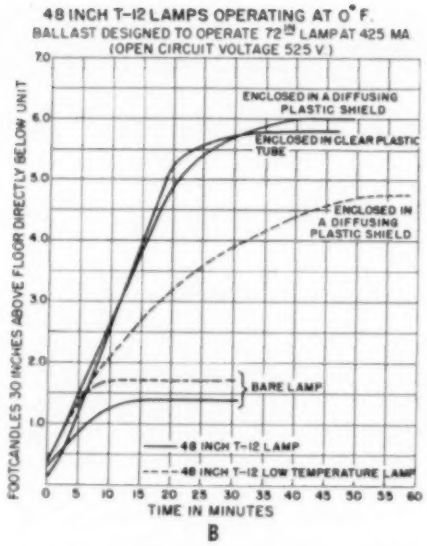
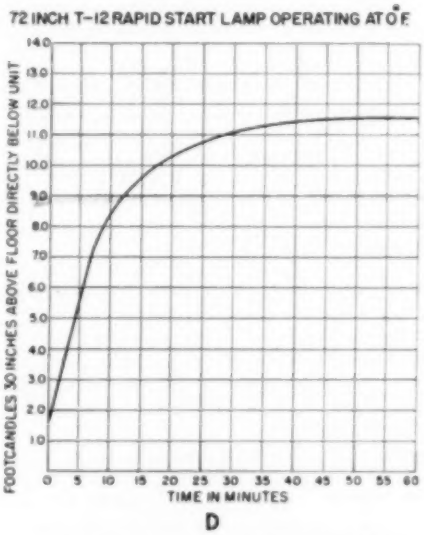

72 INCH T-12 SLIMLINE LAMP OPERATED AT 0° F.
BALLAST DESIGNED TO OPERATE 96" T-12 LAMP AT 425 MA
(OPEN CIRCUIT VOLTAGE AT 625 V.)
FOOTCANDLES 30 INCHES ABOVE FLOOR DIRECTLY BELOW UNIT
ENCLOSED IN CLEAR PLASTIC TUBE
BARE LAMP
LAMP OPERATED ON LEAD SIDE OF BALLAST
LAMP OPERATED ON LAG SIDE OF BALLAST
TIME IN MINUTES
C

Figure 1. Curves of horizontal illumination in footcandles directly under luminaire versus time.


48 INCH T-12 LAMPS OPERATING AT 0° F.
BALLAST DESIGNED TO OPERATE 72" LAMP AT 425 MA
(OPEN CIRCUIT VOLTAGE 525 V.)
FOOTCANDLES 30 INCHES ABOVE FLOOR DIRECTLY BELOW UNIT
ENCLOSED IN A DIFFUSING PLASTIC SHIELD
ENCLOSED IN CLEAR PLASTIC TUBE
ENCLOSED IN A DIFFUSING PLASTIC SHIELD
BARE LAMP
48 INCH T-12 LAMP
48 INCH T-12 LOW TEMPERATURE LAMP
TIME IN MINUTES
B



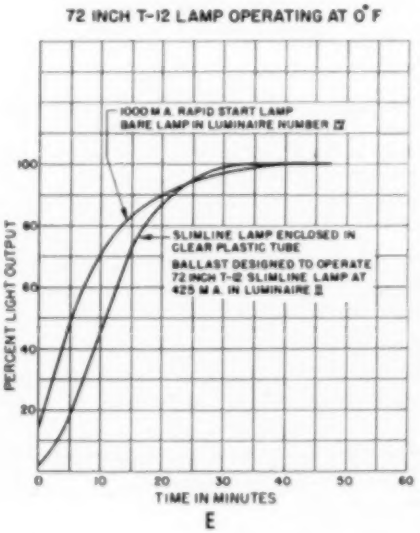
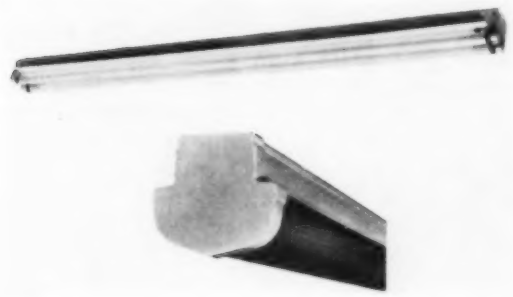

72 INCH T-12 LAMP OPERATING AT 0° F
1000 M.A. RAPID START LAMP BARE LAMP IN LUMINAIRE NUMBER
SLIMLINE LAMP ENCLOSED IN CLEAR PLASTIC TUBE
BALLAST DESIGNED TO OPERATE 72 INCH T-12 SLIMLINE LAMP AT 425 M.A. IN LUMINAIRE
PERCENT LIGHT OUTPUT
TIME IN MINUTES
E

Figure 2. Two-lamp luminaire for use in low temperature areas.



(1) Regular lamp with diffusing plastic shield removed.
(2) Low temperature lamp with diffusing plastic shield removed.
(3) Regular lamp enclosed in diffusing plastic shield.
(4) Low temperature lamp enclosed in diffusing plastic shield.
(5) Regular lamp enclosed in close fitting clear plastic tube.

III. (a) Luminaire—Six-foot single bare lamp unit with ballast for operating 96-inch T-12 slimline fluorescent lamps at 425 ma (625-volt open circuit).
(b) Lamp—72-inch T-12 fluorescent lamp.
(c) Combinations tested:
(1) Bare lamp operating on lag side of ballast.
(2) Bare lamp operating on lead side of ballast.

Figure 3. Views of test room at National Terminal Corporation, Cleveland, Ohio.

A

B

C

D

(3) Lamp enclosed in close fitting clear plastic tube and operating on lag side of ballast.

(4) Lamp enclosed in close fitting clear plastic tube and operating on lead side of ballast.

IV. (a) Luminaire—Six-foot single bare lamp unit with ballast for operating 72-inch T-12 rapid start lamp at 1000 ma.

(b) Lamp—72-inch T-12 rapid start fluorescent lamp.

(c) Combination tested: Bare lamp.

The room in which the units were installed was in constant use during the period of time that the tests were being conducted. Merchandise was stacked on the floor in islands but there was no method of limiting the exact location of these islands. An aisle-way was provided between the islands but the width was subject ot considerable variance as the goods were moved in and out. Also, the cartons and boxes were stacked from the floor level as high as possible (often times only about six inches below the refrigeration coils). Another adverse factor was the circumstance that there was no regulated voltage supply; also, although thermometers were installed at various locations in the room, they did not indicate the *exact* temperature at the unit. If a large number of cartons had just been stored adjacent to the thermometer, the temperature indicated might be several degrees higher than the actual temperature at the luminaire.

For these reasons, no attempt was made to obtain complete photometric data. Instead, a photocell and footcandle meter were used to measure the horizontal illumination at a point 30 inches above the floor and directly below the center of the luminaire which was mounted approximately nine feet above the floor. (This low mounting height was necessitated by the room's relatively low ceiling height of 10 feet 3 inches with the bottom of the refrigeration coils suspended from the ceiling approximately nine feet above the floor.) Thus the readings taken would be primarily direct illumination from the luminaire and the reflected components due to the proximity of cartons would be minimized. For practical purposes the illumination was considered as being entirely due to direct illumination from the luminaire and in a general sense would indicate the relative light output of each lamp and ballast combination.

The luminaires were not operated for at least 24 hours before taking data so that all of the component parts of the units would be at the temperature of the room. The incandescent lamps normally used were not turned on so that the only illumination was from the test unit. Readings were taken at five-minute intervals from the moment the test unit was turned on until the light output became constant. The photocell and footcandle meter were kept outside the room except when actually taking readings as a precaution against the low temperature affecting the operation of the meter. The temperature and voltage readings were approximately 0°F and 118 volts (at the luminaire) respectively throughout the entire period during which all the luminaires were tested. There were no air currents to affect the light output of the lamps.

At no time during the test was trouble encountered in starting the lamps which indicated that the open circuit voltages of the standard ballasts used were sufficient at this temperature for the particular lamps tested. However, this does not mean that the use of the various lamp and ballast combinations tested is recommended. It was realized that the data thus obtained were far from being complete or answering all the possible questions for this type of operation.

Results

Figs. 1-A and 1-C show the horizontal illumination in footcandles directly under luminaires I and III respectively. The solid lines indicate the light output when the lamp is operated on the lag circuit of a lead-lag ballast and the dashed lines indicate the light output when the lamp is operated on the lead side of the circuit.

Fig. 1-B shows the horizontal illumination in footcandles for luminaire No. II when readings were taken as described above. The solid lines indicate the light output of the regular lamp and the dashed lines indicate the light output of the low temperature lamp.

Fig. 1-D shows the horizontal illumination in footcandles directly under luminaire IV.

Fig. 1-E shows the comparison of per cent light output versus time for luminaire III with the lamp enclosed in a clear plastic tube and operated on the lag side of the ballast and luminaire IV.

Fig. 2 shows the two-lamp model of a luminaire for this type of application both as a bare lamp and as an enclosed unit.

Fig. 3-A is a view of the cold storage room used for testing the luminaires when lighted by the old bare incandescent lamp system. The sharp shadows due to the point source are very noticeable. Fig. 3-B shows a section of the test room lighted by a single experimental luminaire. The vertical illumination of the cartons is adequate and although

shadows are present this is due to the light coming from only one side. Fig. 3-C is another view of the test installation as viewed from a passage-way. Fig. 3-D is representative of the many hours spent in the area reading test data. This single row of luminaires over the aisle provides good visibility.

Based on these preliminary results, a room 100 feet x 100 feet with a 15-foot mounting height ("C" room index), 75-50 per cent reflectance and a temperature of 0°F, would require 68 single bare lamp luminaires utilizing the 100-watt rapid start lamp, or 58 bare 200-watt inside-frost incandescent lamps to provide a maintained in-service illumination level of 10 footcandles. This results in a BTU per hour heat load of 28,500 for the installation of fluorescent lamps and 39,600 for the installation of incandescent lamps. This is a reduction of 28 per cent in the generated heat load when using fluorescent lamps rather than incandescent lamps.

Conclusions

From the curves it can be seen that the slimline lamps when operated at this temperature without being enclosed provide very little light output. However, when the lamps are enclosed, the light output is raised considerably as a result of the increased bulb wall temperature. Fig. 1-A indicates very little difference in the light output whether a small close fitting clear plastic tube is used or a larger plastic enclosure of a type that fastens on the luminaire is used. Based on the limited amount of information available at this time, the choice between the slimline lamps enclosed in a tube and the 1000 ma rapid start lamps without an enclosure would depend entirely on the conditions for any specific installation. The advantages of the 1000 ma lamp would be more light output immediately after starting and no enclosure to be handled when relamping or cleaning the luminaires. At a temperature of −45°F, it is doubtful if the slimline lamps would be suitable even when enclosed. However, the rapid start lamp when enclosed would probably prove to be satisfactory.

In order to verify the test data completed in the field and to obtain more complete and precise information over a wide range of ambient temperature conditions, laboratory tests were initiated. These tests are now being conducted and the complete information is not yet available.

The author wishes to express his appreciation to Mr. H. C. Diehl, Director and Secretary of the Refrigeration Research Foundation, and Mr. A. B. Efromson, President of the National Terminals Corporation, for their assistance and cooperation in obtaining the data presented in this paper.

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DISCUSSION

B. A. WILSON:* This study is an important addition to our knowledge of the operation of fluorescent lighting in cold applications. It is particularly interesting because the tests were made in a temperature area on which we have not had much previous information. In so far as the lamps used, the paper is valuable because there has been considerable confusion among lighting consultants regarding the proper lamps to recommend. This paper will help considerably to solve these problems. I feel I cannot add anything further regarding the lamps.

There is one comment I can make regarding the mechanical design of the fixtures and that is that our experience has shown that, due to humidity and possible frosting conditions, it is wise to stay away from bare sockets and open electrical contacts. I would suggest that completely porcelained or otherwise rust-proofed fixtures be used and it is a foregone conclusion that the lamps should be enclosed; perhaps, a more simply constructed fixture could be designed for applications such as these. That is, simpler fixtures than the present vapor-proof models already on the market. A broad distribution would also be preferable in many locations.

W. CALVIN GUNGLE:** The work presented in this paper is of value to the lighting industry as it extends the temperature range where information is available on fixture operation of fluorescent lamps to zero F. Unfortunately the author did not report any data at −45F and it is hoped that this paper will stimulate further investigations in the low temperature range.

As brought out in the paper, a 425 ma bare lamp unit is of no practical value when ambient temperatures in the vicinity of zero F and lower are encountered. By placing an enclosure around the unit the light output is increased by an average of 400 per cent as shown by the curves in the paper. An even greater increase in light output, from the heavily loaded rapid start lamp units, would be expected by enclosing this type unit. The increase in light from each heavily loaded fixture would reduce the total number of fixtures needed to obtain the desired level of light. This in turn would reduce the heat load further.

When evaluating the disadvantages of enclosed fixture units in this application with regard to cleaning and relamping, two points should be remembered. Fluorescent lamps are rated at 7500 hours, or over a year of continuous burning. Dirt collection on the units would be a minimum since vertical convection currents would be small. In view

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**Sylvania Electric Products Inc., Salem, Mass.

of this, would not the disadvantages of enclosures be minor in comparison to the advantage to be obtained by their use?

Due to the need for a high open-circuit voltage to obtain reliable starting, the designed lamp ballast was not always used, which undoubtedly altered the operating lamp parameters. In addition, low temperature operation will materially affect operating lamp parameters. Under the conditions of testing what were the lamp parameters during operations, especially the lamp powers and current crest factors? This information is of importance in evaluating this application of fluorescent lighting as the operating lamp parameters can accentuate discoloration and shorten lamp life.

The effect of temperature on starting fluorescent lamps for temperatures as found in this application need not be of too much concern. If the advantages of fluorescent lamps are sufficiently great, a ballast can be designed to insure reliable starting.

As reported in the paper, the lamp ambient temperatures were not measured. These values would be a valuable addition to the paper as the temperature may be higher than realized especially for enclosed fixtures where they may be 20-30C higher than the surrounding room temperature. This measurement can be made quite simply with the use of a thermocouple placed near the lamps.

BENJAMIN S. BENSON, JR.:* The choice of whether to use fluorescent or incandescent, or indeed mercury, lighting in cold storage areas depends to a considerable extent upon the nature of the lighting problem and the economics of the various solutions. I am not sure that I have the same definition of a "Dead Storage" area as Mr. Summers but I visualize it as one not so much associated with the severity of the seeing as with the frequency of use of such an area.

If a cold storage area is very inactive it would be, in all probability, most economical to use incandescent and operate the lighting only when employees are actually in the area. If the lighting is used for only short periods of time, the savings in power by using fluorescent will hardly begin to pay for the much higher initial investment necessary.

While incandescent lighting will provide more Btu's per hour than fluorescent (under conditions of equal footcandles), if the lighting is to be used only a few hours per year this comparison has little significance.

For live storage using lighting throughout the working day, the use of fluorescent, or mercury, has great possibilities.

*Benjamin Electric Mfg. Co., Des Plaines, Ill.

The curves relating light output to operating time for the various lamps and equipments tested at zero degrees are of continuing interest in the study in variations in lighting results. It would have been interesting for the author to include data for other temperatures.

The author's photographs of the test room show quite severe shadow conditions for both the incandescent and fluorescent installations. I would say that his explanation for the fluorescent would apply equally well to the incandescent. Because of the high piles of goods usually found in such areas closer spacing of the lighting units is very much indicated.

T. SUMMERS:* The discussion coments are most welcome and appreciated.

In regard to Mr. Wilson's suggestion that the unit be completely porcelained or otherwise rust-proofed, the unit is porcelain enameled steel and is available either as an enclosed or a bare lamp unit. In either case the unit has a broad light distribution.

The disadvantage of an enclosure would be minor when compared to the advantage obtained at low temperatures as pointed out by Mr. Gungle. The lamp operating parameters were not obtained as this was a field installation rather than a laboratory installation. The area is located in a commercial warehouse and is in continual use. Also, it was impossible to obtain data at any temperature other than zero degrees F. However, laboratory tests are being conducted in which all parameters as well as the lamp ambient temperatures are being recorded at various temperatures.

The term "dead-storage" as pointed out by Mr. Benson could indicate that the area is seldom used. Perhaps this is a poor choice of words but the term was meant for the goods not the area. Any particular skid would remain in one place for a considerable length of time, but there is considerable activity moving goods in and out when considering the whole area.

The photographs showing the fluorescent installation do indicate shadows. However, these shadows are not as sharp as that from the incandescent installation.

It was realized that a proper spacing-to-mounting height ratio was not used in the installation of the test units but due to the limitations involved it was felt that this would be suitable for test purposes. Even when the excessive spacing was used, the results were a vast improvement over the old system.

*Author.

Exercise your privilege to vote . . .

in the election of National and Local I.E.S. Officers and on other Society changes. Your ballots will be reaching you early in April.

INSTALLATION AT WORTHINGTON, OHIO.

Lighting a Bath and Health Room

LIGHTING OBJECTIVE: To provide recommended levels of local and general lighting in a bathroom plus safe and comfortable conditions for sun-tanning.

GENERAL INFORMATION: Fig. 3 shows the plan view of this room. Ceiling height is 8 feet. The lavatory counter tile is light gray (70 per cent reflectance), and the wall above and ceiling are very light pink (75 per cent reflectance).

INSTALLATION: A plastered 15¾-inch deep cornice extends the entire length of the sunning table at one side, and there is similar construction above the lavatory counter on the other side of the room. Back of these cornices the ceiling is furred down to the necessary depths (see Figs. 4 and 5) to recess the lighting equipment.

Each lavatory is lighted by a recessed 10-inch by 21-inch two-lamp Prescolite No. 820-6120 luminaire with polished reflector and Alba glass cover. Each unit contains two 75-watt incandescent filament lamps. Illumination measurements on a person standing at the counter edge were as follows:

	Between Lavatories	In Front of Lavatory
On forehead (64" above floor)	75 ft-c	100 ft-c
On cheeks	45 ft-c	45 ft-c
On chin	25 ft-c	25 ft-c

(over)

A.I.A. File No. 31

Figure 2. Close-up showing sunning table.

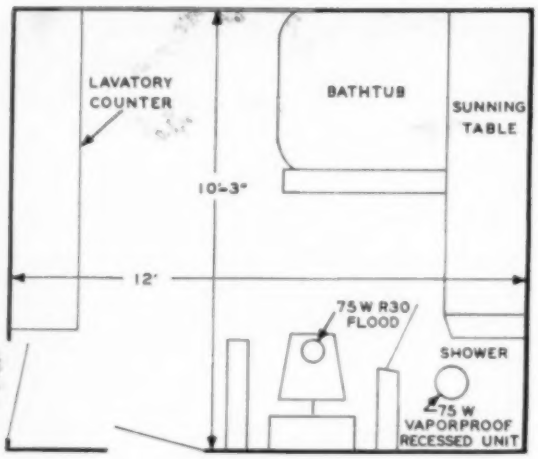

Figure 3. Plan view.

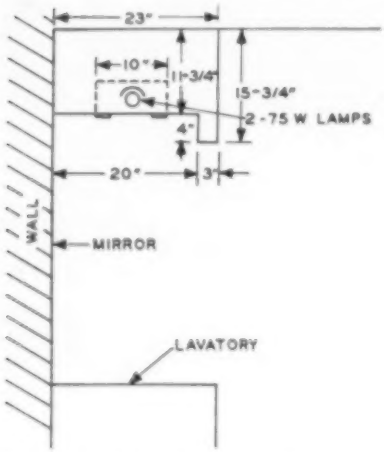

Figure 4. (above) Detail of plaster cornice and recessed lighting unit above lavatories and mirror.

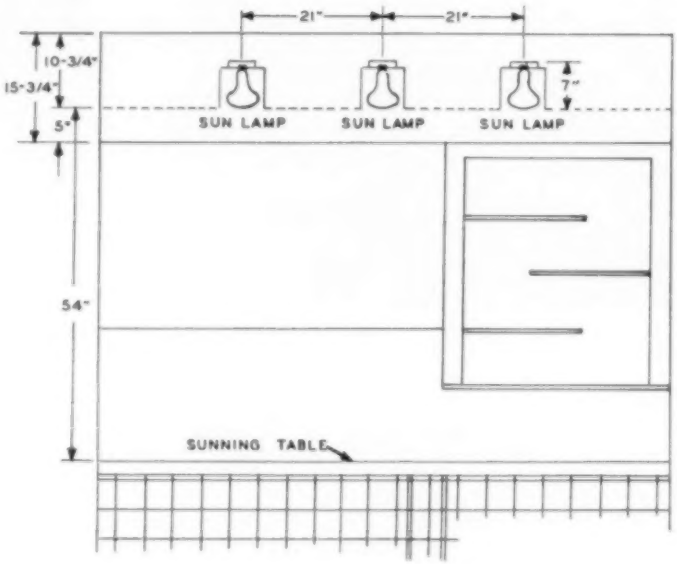

Figure 5. (right) Detail showing installation of sun lamps.

The shower is lighted by a recessed vapor-proof luminaire using a 75-watt lamp. Over the toilet there is a recessed downlight using a 75-watt R-30 flood lamp.

Three 275-watt RS sunlamps are recessed on 21-inch centers in Prescolite No. 70 open-bottom downlights (7-inch diameter) 54 inches above the pad on the sunning table as shown in Fig. 5. The owner also has three infrared lamps which he uses in these outlets occasionally for heat therapy.

Lighting data submitted by Blanche Waggener, Columbus and Southern Ohio Electric Company, Columbus, Ohio, as an illustration of good lighting practice and to aid in the design of similar installations.

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Mercury and Filament Lighting Can Be Comfortable Too

By E. A. LINSDAY
Q. D. DOBRAS
D. R. PHILLIPS

INDUSTRIAL lighting quality has improved markedly in the last few years. The need for this improvement and the advantages to the worker and to management has been universally accepted. The improvements, however, have generally been limited to fluorescent lighting systems. These fluorescent systems incorporate marked improvement in luminaire design. Fig. 1 shows a typical illustration of modern industrial luminaire. The basic improvements have been increased shielding (35 degrees crosswise), upward light (approximately 25 per cent), and a white finish on the outside of the luminaire. In addition 25-degree lengthwise shielding is often used where the predominate viewing direction is lengthwise. Besides these luminaire improvements there has been wide acceptance of the lighter room finishes which are an important adjunct to brightness control. All these improvements make it possible to obtain higher lighting levels comfortably. Thus, better visibility with its attendant advantages can now be provided for the many difficult seeing tasks in industry.

The application of fluorescent installations has been used primarily at relatively low mounting. There remains a sizable portion of industry where high mounting is required. Here, the higher brightness sources (filament and/or mercury) are generally the logical choice because of their greater lumen output and correspondingly lower maintenance costs because of the fewer number of units to be serviced. It is the purpose of this paper to look into the possibilities of improving comfort for these higher brightness systems and to encourage the development of improved lighting equipment and the application of it in these areas. The need for more comfortable lighting installations in high mountings is borne out by the growing acceptance of fluorescent installations for these areas.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 12-16, 1955, Cleveland, Ohio. AUTHORS: Application Engineering, Large Lamp Dept., Lamp Division, General Electric Co., Nela Park, Cleveland, Ohio.

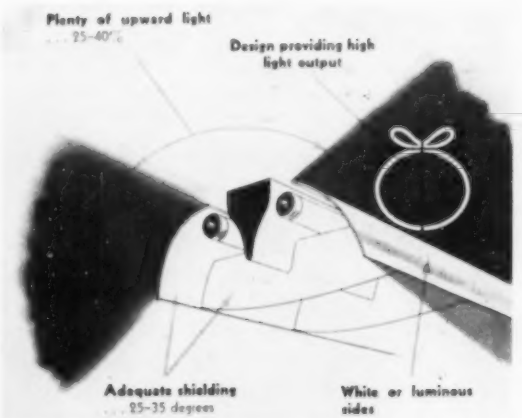

Figure 1. Improved comfort is obtained with the new types of industrial fluorescent fixtures because of their better shielding, upward light, and white exterior finishes.

Fluorescent Systems

A fluorescent installation that illustrates a comfortable environment resulting from the most modern design of industrial lighting equipment is shown in Fig. 2. It must be realized, however, that in order to obtain this comfort with fluorescent systems a well planned maintenance program is essential. These large area, low brightness sources, suffer more from lack of maintenance than do the high brightness sources. Maintenance costs, however, are steadily being reduced as the fluorescent sources are improved. Two new developments hold significant promise in this direction.

(1) A new 8-foot, high-output rapid start lamp produces one-third more light than the corresponding 8-foot slimline. Therefore, the initial investment in the lighting system is reduced proportionately as is the cost of maintaining this system.

(2) The Union College Field House[1] in Schenectady, New York, (Fig. 3) is an example of a high frequency fluorescent lighting system applied

Figure 2. A quality fluorescent lighting system at a relatively high (22 ft.) mounting is illustrated. The result is a pleasant comfortable working environment conducive to easier seeing and better quality work.

to a high area. This is the first large installation of high frequency for general lighting. Reduced maintenance cost are obtained by "ganging" lamps into large fixtures. Each fixture in this installation contains 14 8-foot slimline lamps. Because of the high frequency supply the ballasts are much smaller, consequently the fixtures are light in weight and could be mounted on disconnecting hangers for lowering to the floor for easy maintenance. A substantial initial cost advantage in this high frequency system is obtained because of higher voltage distribution (600 volts center tapped to ground). Operating costs are substantially lower than the filament-mercury system originally considered for this building.

Figure 3. High frequency fluorescent lighting with large area fixtures (14 — 96T12 slimline lamps per fixture), is used at the Union College Field House in Schenectady, New York. Thus, a great improvement in comfort is obtained at less cost than the combination mercury-filament system originally considered for this building.

Another interesting possibility[2] with high frequency operation of fluorescent lamps is the adjustment of light output by control of output current to maintain a constant lighting level[3] as the system depreciates due to normal lamp depreciation and dirt accumulation. Fig. 4 shows a cafeteria installation in which this technique was first used. A constant lighting level of 70 footcandles is maintained.

Another method of minimizing maintenance costs with fluorescent systems is the construction of special maintenance devices to simplify the task

Figure 4. A constant lighting level of 70 footcandles is maintained in this cafeteria. A magnetic frequency converter supplies adjustable output high frequency power to the fluorescent lighting system.

of getting to the fixtures for service. Fig. 5 shows an installation of maintenance cages at North American Aviation Corporation which, while somewhat expensive in first cost paid for itself in the first cleaning and group relamping of the installation.

Comfort Evaluation[4]

Visual Comfort Index (VCI) is a way of evaluating the relative comfort of lighting systems. In Table I the visual comfort indices for the older type industrial fluorescent luminaires are shown along with those for the more modern type. This table is based on a maintained lighting level of 50 footcandles in a room with ceiling of 50 per cent reflectance and walls of 30 per cent. It is apparent that the modern type luminaires are comfortable for the majority of the people viewing them from

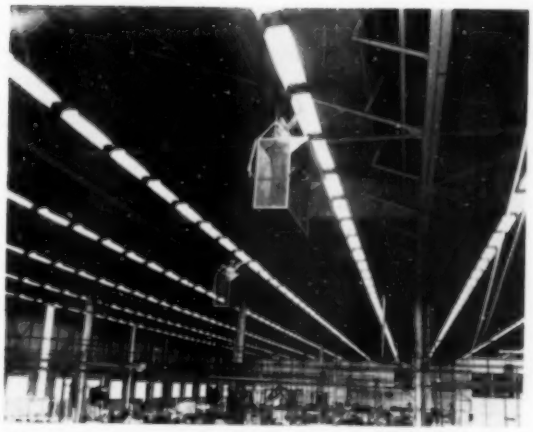

Figure 5. Fluorescent lighting at high mounting is maintained economically at the North American Aviation Corporation in Los Angeles. This maintenance cage and cableway system beneath each row of fixtures reduces the cost of getting the maintenance man to the fixtures.

the worst position in the room when this viewing condition is crosswise of the luminaires. The older type units are consistently uncomfortable under the same conditions.

Let us now consider the possibility of bringing to those industrial areas which logically use filament or mercury lamps the same benefits which have been made available to the industrialist using fluorescent lamps.

TABLE I.

Lamp	Fixture	Efficiency %	Coefficient of Utilization[1]	Shielding Angle	Upward Light[2] %	VCI[3]
FLUORESCENT						
2-96T12	Porcelain	80	.48	13°	0	*
2-96T12/RS	Porcelain	79	.47	13°	0	*
2-96T12	Porcelain	83	.43	35°	28	75
2-96T12/RS	Porcelain	82	.42	35°	28	63
FILAMENT OR MERCURY						
1000WPS52 clear	Porcelain[4]	83	.52	27°	0	*
H400-E1	Porcelain[4]	78	.52	29°	0	*
H400-J1	Porcelain[4]	77	.51	23°	0	*
H400-RC1	Porcelain[4]	85	.55	13°	0	*
1000WPS52 clear	Experimental Aluminum	81	.49	38°	15	90+
H400-E1	Experimental Aluminum	79	.51	40°	25	90+
H400-J1	Experimental Aluminum	81	.52	35°	22	90+
H400-RC1	Experimental Aluminum	82	.52	35°	19	90+

*Computations indicate less than 5 per cent.
1. Room Index G. Reflectance — Ceiling 50%, Walls 30%.
2. Per cent of fixture output directed upward.
3. VCI (Visual Comfort Index) indicates the percentage of people that would be expected to judge a particular lighting system as comfortable when they view it while seated at a point near the middle of the back wall. These VCI's refer to crosswise viewing of fluorescent fixtures. Calculations in this table are for a maintained lighting level of 50 footcandles in a room 80 by 140 feet with a 44-foot mounting height, 50% ceiling reflectance, and 30% wall reflectance.
4. Deep bowl porcelain enamel reflector.

Filament and Mercury Systems

In order to make these systems more comfortable, the same principles of luminaire design which have been utilized in the fluorescent luminaire improvement need to be applied to these brighter sources. Most present day equipment does not have adequate shielding or upward light. It seems logical that proper design of such fixtures should result in good efficiency plus markedly improved comfort. This will more than offset any possible increased cost due to lower coefficients of utilization or higher fixture cost.

In order to determine the possibilities of such designs, an experimental anodized aluminum reflector was designed as illustrated in Fig. 6. This fixture was designed specifically for the H400-RC1 color improved mercury reflector lamp. It was felt that if good results could be obtained with such a large area light source, they could also be obtained with smaller area sources such as clear filament and mercury lamps. This fixture was designed to provide 35-degree shielding to the edge of the bulb and approximately 20 per cent upward light. The fixture has a diameter of 20 inches and the upper opening is 10 inches in diameter. Fig. 7 shows a drawing of the contour. The reflector is designed so that light is emitted from the fixture with a minimum of absorption. Also, the light distribution is designed to provide good vertical footcandles at any mounting height. Fig. 8 shows a photometric curve of this unit. It will be noted that the total efficiency is 82 per cent and the upward component of light is 18 per cent of this. Three other lamps were used in this same fixture. Table I shows the results. Although the fixture is

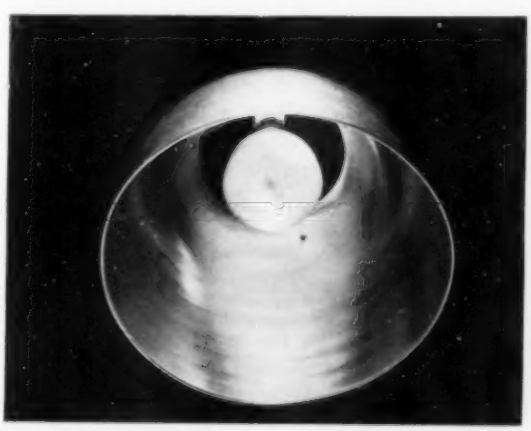

Figure 6. This experimental anodized aluminum reflector is designed for use with the H400-RC1 lamp. Bulb shielding is 35°. 18% of the fixture output is upward because of the 10" diameter opening in the top of the fixture.

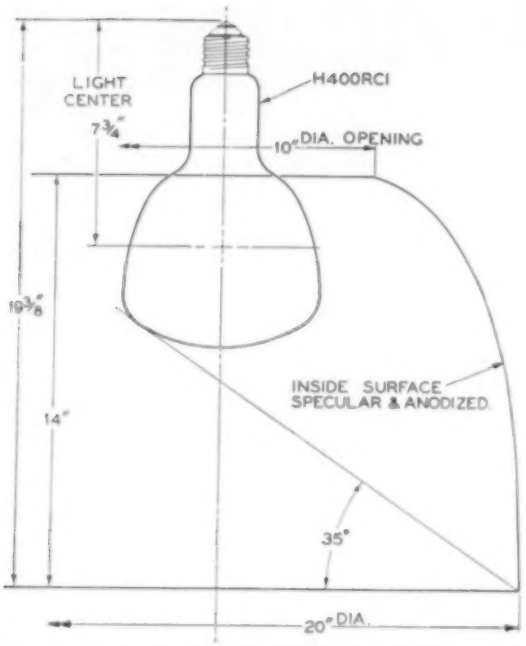

Figure 7. Reflector contour of the experimental anodized aluminum reflector with upward light and good shielding.

not specifically designed for these lamps, it is interesting to note that with approximately the same degree of shielding the efficiencies are still about 80 per cent. Probably fixtures specifically designed for each lamp would be somewhat more efficient.

Where moisture condensation on the lamps is a possibility, a glass or plastic shield can be designed to close the opening in the top of the fixture. However, it should be pointed out that adequate ventilation in the husk of the unit should be provided in order to minimize dirt accumulation on the inside of the reflector. It might also be mentioned that the experimental fixture was made of commercial spinning aluminum and it might be possible to improve the efficiency by use of higher grade material. The reflector was, however, anodized and commercially brightened to maintain as high a reflectance as was possible with the sample unit.

Comfort Evaluation[4]

Table I lists VCI's for installations of the experimental unit with several sources as well as VCI's for a typical present day unit incorporating the same lamp types. It will be noticed that the VCI's for the experimental unit are all above 90 per cent, which is even higher than the VCI's shown for the quality fluorescent units. The reason for this difference is the use of an aluminum reflector which is lower in brightness at normal angles of view as compared with the white finish reflectors used with the fluorescent lamps. Similar improvements are to be expected with the latter sources if aluminum reflectors are employed. It will also be noticed that the VCI's for typical present day industrial equipment with filament and mercury sources are below 5 per cent.

Cost of Light Comparison[5]

Fig. 9 gives an idea of costs for several types of lighting systems which might be used at high mounting in industry. The 1000-watt PS-52 lamp in a standard non-ventilated deep bowl porcelain luminaire is used as a base for comparison. It should, however, be recognized that in any specific installation these figures should be modified to correspond to the particular conditions which apply. It is interesting to note that the fluorescent systems are lower in overall costs than the filament systems and that the modern comfortable fluorescent lighting system is no higher in cost than the older, much less comfortable, fluorescent systems. It will, also, be noted that fluorescent installations are of the same order of cost as combination mercury-filament installations. Mercury lighting is somewhat lower in cost than either the filament or fluorescent. When the filament and mercury systems in the experimental luminaire are compared to the corresponding systems incorporating present standard non-ventilated luminaires, it will be noticed that the costs are nearly the same. In fact, in most cases costs are slightly lower for the experimental units. It should be pointed out that ventilated units of the standard type show an overall cost of light of 5-10 per cent lower. This is due to the improved maintenance factor which results from this construction. Cost of light with ventilated standard equipment is therefore approximately 5 per cent lower than systems employing the experimental units. However, the markedly improved comfort obtained with the experimental unit more than compensates for any slight additional cost.

In many industrial areas reflected glare is a problem. Lower brightness, larger area sources are much to be preferred in such areas. Fluorescent lamps, therefore, will undoubtedly be used more and more in these places as compared to the higher brightness filament-mercury systems. However, it would be well to point out that the modern fluorescent units with upward light and the correspondingly balanced brightness which results are substantially better from a reflected glare standpoint than the older solid top units. Similar reduction in reflected glare will be obtained by substantial

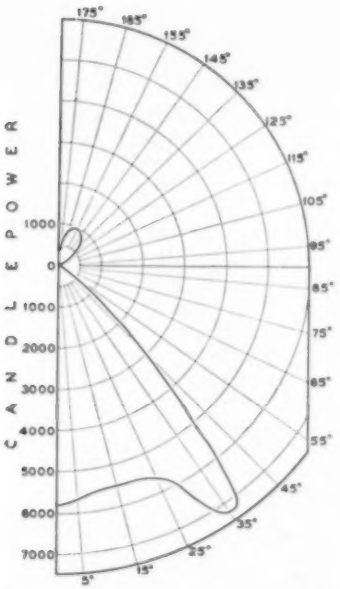

Figure 8. Photometric curve of experimental anodized aluminum reflector with 10" opening in top for upward light.
Shielding (of bulb) is 35°.
Lamp — H400-RC1
Watts — 400
Lumens — 19,000
Bulb — R-52 (Phosphored)

Test Distance — 10'

Zone	Lumens	% Total Lamp Lumens
0-30	4,734	26.3
0-40	9,148	50.8
0-60	11,773	65.4
0-90	11,947	66.4
90-180	2,836	15.7
0-180	14,783	82.1

% based on lamp lumens of 19,000

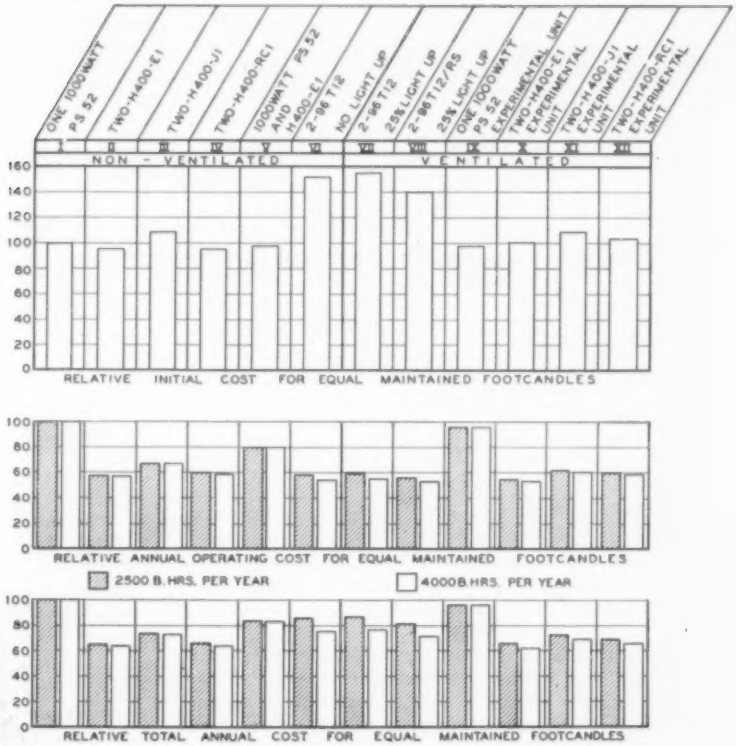
ONE 1000 WATT PS 52
TWO-H400-E1
TWO-H400-J1
TWO-H400-RC1
1000 WATT PS 52 AND H400-E1
2-96 T12
NO LIGHT UP
2-96 T12
25% LIGHT UP
2-96 T12/RS
25% LIGHT UP
ONE 1000 WATT PS 52
EXPERIMENTAL UNIT
TWO-H400-E1 EXPERIMENTAL UNIT
TWO-H400-J1 EXPERIMENTAL UNIT
TWO-H400-RC1 EXPERIMENTAL UNIT
I II III IV V VI VII VIII IX X XI XII
NON - VENTILATED
VENTILATED
160 140 120 100 80 60 40 20 0
RELATIVE INITIAL COST FOR EQUAL MAINTAINED FOOTCANDLES
100 80 60 40 20 0
RELATIVE ANNUAL OPERATING COST FOR EQUAL MAINTAINED FOOTCANDLES
2500 B.HRS. PER YEAR
4000 B.HRS. PER YEAR
100 80 60 40 20 0
RELATIVE TOTAL ANNUAL COST FOR EQUAL MAINTAINED FOOTCANDLES

Figure 9. Cost analysis, industrial lighting systems, high mounting.

upward light from units using the higher brightness sources.

Summary

Modern industrial lighting is a production tool. Worker efficiency depends not only on amount of illumination but on pleasant comfortable working environment. Lighting equipment for comfortable lighting systems with fluorescent luminaires is becoming an industry standard. From the data presented in this paper it is quite apparent that it is equally feasible to provide markedly improved environment in those areas where filament and mercury sources are applied. It is hoped that this paper will point out the need for better lighting systems in such areas and will indicate methods of accomplishing this goal effectively. It is possible, at essentially no increase in cost to have 90 per cent of the workers comfortable in an area where well designed fixtures are installed as compared to less than 5 per cent who consider present typical installations, comfortable. Certainly the goal of the industrial illuminating engineer is more effective and more comfortable workers. It goes without saying that where workers can see better they can work better.

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DISCUSSION

R. D. BRADLEY:* I wish to compliment the authors of this paper on preparing a parallel to the Taylor-Bradley paper entitled "Visual Comfort and Cost Analyses for Production Lighting" (to be published).

We did not know that the authors were preparing this

*Day-Brite Lighting Inc., St. Louis, Mo.

paper; however, it is so closely parallel to our paper on fluorescent lighting as to almost act as a double-check on the conclusions arrived at, indicating that similar conclusions could be reached for all forms of interior industrial lighting.

I was quite interested in the discussion of high-frequency installations and feel that the study of economics of this new system will be quite interesting and certainly should be compared to our more conventional types of installations.

The authors mention that ventilated units of a standard type show an overall cost of light of 5-10 per cent lower, due to the improved maintenance factor which results from this construction. This is approximately the same figure used by these authors for fluorescent systems (5 per centage points for ventilated fluorescent fixtures). It would be interesting to have more definite data as to the exact amount of depreciation which could be expected for various types and wattage light sources, when used under ventilated conditions.

KURT FRANCK:* The authors have done a valuable service by providing confirmation of the fact that mercury and filament lighting has a definite place in modern industrial lighting installations. The data they present support their statement that mercury and filament lighting can be comfortable; in fact they go beyond it by showing on the basis of cost analyses that mercury can also have economic advantages over comparable fluorescent installations. In this respect, we believe that the tables given in the paper allow more forceful conclusions than the authors have drawn in the text of their paper.

The visual comfort index values obtained for the experimental reflector which the authors analyzed are so favorable that we can also expect a high degree of comfort when these units are used not only at high mounting heights, as assumed by the authors, but also for standard low-bay industrial lighting. Actual experience bears this out; we have had the opportunity of observing the performance of commercially available reflectors, providing both good downward shielding and a sufficient component of upward light and mounted in actual installation at standard low-bay mounting heights of approximately 14 feet; the results with color-improved mercury lamps in these reflectors are indeed remarkable for their excellent visual comfort.

From the standpoint of economics the authors state in the text that "Mercury lighting is somewhat lower in cost than . . . fluorescent." Actually comparisons of columns VII and VIII in Fig. 9, giving the cost analysis of typical fluorescent units, versus columns X, XI and XII, for mercury lamps in the authors' experimental reflector, shows total annual cost for equal maintained footcandles to be quite considerably less (in the order of about 15 per cent) for mercury than for fluorescent. This cost advantage is reasonable to expect, since mercury and fluorescent are comparable on the basis of lumens per watt and lamp life; the greater concentration of lumens per luminaire, which mercury affords over fluorescent, gives mercury a significant edge on cost.

One question: In preparing the cost analysis have the authors based their figures on up-to-date high maintenance labor costs?

W. H. KAHLER:** The data presented in this paper will be helpful to reflector designers because they emphasize two important points that lead to greater comfort with high brightness sources. One is the effect of upward component of illumination to relieve harsh brightness differences between the sources and the background.

The other point is the effect of shielding angle, I have always felt that many high bay reflectors were too shallow and the resulting poor shielding angle creates a condition of discomfort. Lighting system designers can greatly improve comfort by specifying the shielding angle of equipment and 35 degrees seems to be a reasonable minimum, even with conventional ventilated reflectors. Equipment is available today with adequate shielding and specifiers should insist on its use.

The cost analysis, Fig. 9, shows upward component high bay systems to cost about the same as non-ventilated direct systems. I believe the main economic question in this paper is the cost of the upward component lighting. The text covers this point but I feel that Fig. 9 would be more informative if it had been based upon ventilated direct reflectors vs. upward component reflectors.

E. A. LINSDAY, Q. D. DOBRAS, D. R. PHILLIPS:* We wish to thank the various discussors for their comments which serve to clarify some of the points in the paper.

The close correlation between some of the data in this paper and corresponding data in Mr. Bradley's paper indicates that the basic assumptions are approximately the same — especially in regard to maintenance factor. Much work has been done by Mr. VandenBoom and Mr. Egeler[1] on this subject, as well as Mr. Floyd Sell.[2] Their work was the basis for much of the maintenance data used in our paper. We agree, however, with Mr. Bradley that much more data are needed on this subject to further improve the accuracy of design and cost data. Economic studies of high frequency lighting were not included in the paper because (1) it is still relatively new; thus data and developments on this system are still forthcoming; (2) it is more difficult to get typical costs of high frequency systems since a fair cost comparison should include the whole distribution system.

Lighting systems using filament and mercury lamps in low-mounted, well-shielded equipment would have good comfort from a direct glare standpoint, as Mr. Franck points out. At these heights, however, fluorescent systems begin to appear more attractive due to lowered maintenance costs, less disturbance from reflected glare and the ease of obtaining good light coverage. Maintenance costs were calculated with today's high labor costs in mind. Lamp replacement costs of $1.50 and cleaning costs of $.60 per fixture were used for the filament and mercury lamps. While both higher and lower costs are encountered in industry, the authors believe that these figures are fairly typical.

Mr. Kahler pointed out that the cost comparison could have been made between ventilated and upward component reflectors. We chose the non-ventilated reflectors because we felt they were more typical of present-day practice. However, we did consider the other comparison and stated in the paper that the cost of light with ventilated standard equipment was approximately 5 per cent lower than systems employing the experimental units.

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*The Holophane Co., Newark, Ohio.
**Westinghouse Electric Corp., Cleveland, Ohio.

*Authors.

INSTALLATION AT BOWEN SCHOOL, 280 CYPRESS ST.
NEWTON CENTRE, MASS.

Lighting a Low Ceiling Classroom

LIGHTING OBJECTIVE: To provide a minimum of 30 footcandles maintained and meet recommended brightness ratios by means of fluorescent lighting in a classroom with a low ceiling.

GENERAL INFORMATION: The first grade classroom shown above measures 36 feet by 23 feet, ceiling height is 10 feet 8 inches. Surface characteristics are as follows:

ceiling, acoustical tile	white	80% RF
walls		
upper	light green	64% RF
lower	light green	55% RF
floor, asphalt tile	mixed, light gray and light tan	30% RF
chalkboard	light green	20% RF
tackboard	light green	20% RF
desk top, unstained birch	blonde	34% RF
furniture, unstained birch	blonde	34% RF

(over)

A.I.A. File No. 31

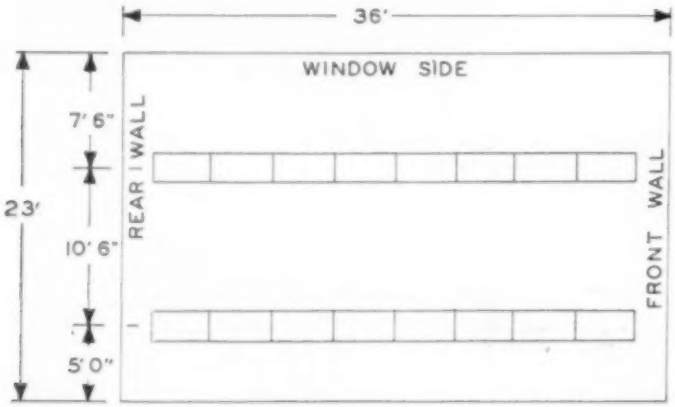

Figure 2. Plan view of classroom showing location of lighting equipment.

INSTALLATION: Sixteen pendant mounted luminaires (Sylvania Electric Products, Inc. catalog No. CP-242) are suspended 21 inches overall and located in two rows, spaced 10 feet 6 inches apart, as shown in Fig. 2. Each luminaire is equipped with two 40-watt T-12 3000K warm white pre-heat starter type fluorescent lamps. Average general illumination after 600 burning hours, on a plane 22 inches above the floor (desk top height) measured 35 footcandles. Brightnesses were as follows:

luminaire	260 ft-L
ceiling, maximum	130 ft-L
front wall, center	
upper	17 ft-L
lower	12 ft-L
side wall, upper	23 ft-L
floor	10 ft-L
chalkboard	6 ft-L
tackboard	6.6 ft-L
desk top	17 ft-L
white paper on desk	41 ft-L

Lighting design specified by William F. Clark, Director of Business Services, Newton Public Schools, Newtonville, Mass.; Architect: Louis W. Ross, 131 State St., Boston, Mass.; General Contractor: C. R. Burns & Sons, 21 Doran Road, Brookline, Mass.; Electrical Contractor: Balcom Electrical Co., Inc., 27 Irving Court, Malden, Mass.

Lighting data submitted by Alonzo Taylor, Lighting Engineer, Boston Edison Co., 39 Boylston Street, Boston, Mass., as an illustration of good lighting practice and to aid in the design of similar installations.

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A Study of Lamp Mortality and Lumen Depreciation of MERCURY LAMPS As a Guide to

Relamping Programs

By W. S. TILL
M. E. HASKINS, JR.

THE INCREASING popularity of mercury lamps, particularly in industrial and street lighting applications, has drawn attention[1,2] to the fact that their *actual* life is much longer than their *rated* life. A gradually declining light output throughout life has led many persons to wonder at exactly what point the lamps might have outlived their usefulness. Widespread interest has therefore developed in knowing whether it would pay to relamp systematically, that is, by group replacement or by some other method, in mercury lamp installations. It is the purpose of this paper to point out:

1. methods of relamping,
2. characteristics of the light source having a bearing on the problem,
3. method of economic analysis.

Group relamping has gained acceptance for incandescent and fluorescent lamps, but has met with little consideration for mercury lamps because of lack of data[3] and important differences in lamp price and essential characteristics, as shown in Table I.

TABLE I — Comparison of Light Sources.

	Incandescent (1000-Watt)	Fluorescent* (F90 T17)	Mercury** (400W E-H1)
List Price	$2.80	$2.70	$18.40
Rate Average Life (Hours)	1,000	9,500	6,000
Average Life to 90% Burn-Out (No. of hours by which 90% of lamps will burn out)	1,250	12,000+	16,000+
Relative Mean Lumens for Rated Life and Watts	83%	85%	81%

*At 6 burning hours per start.
**At 5 or more burning hours per start.

Because mercury lamps cost so much more per socket compared with other light sources, many users do not consider removing them from service as long as they still produce light. In a few instances 250-watt quartz mercury lamps have been kept in service as long as 80,000 hours. Their light

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High-bay installation of mercury lamps. Where lamps are fairly inaccessible, relamping costs are high and group relamping offers considerable savings.

Low-bay installation of mercury lamps. Although relamping costs are relatively low in areas such as this, group relamping can result in worthwhile savings as well as in improved lighting.

output, however, was extremely low. Earlier relamping would have given more satisfactory results: better maintained footcandles, more uniform lighting, and lower cost.

How does one decide when to relamp? The first step might be to consider relamping methods now in use for mercury lamps in street and industrial applications. The following plans have come to the attention of the authors:

1. *random* — lamps are replaced *only* when they burn out.
2. *retirement* — lamps are replaced individually:
   a — when they reach a certain age, or
   b — when they have dropped to a certain point in light output.
   — lamps that burn out prior to this time are replaced as they burn out.
3. *group* — all lamps in the installation are periodically replaced at one time. Lamps that burn out prior to this time are replaced as they burn out.

A variation of the group plan is to leave burned out lamps in their sockets until all the lamps are group replaced. While this method may be practical for fluorescent lamp installations where the number of lamps in a given area is large, it is not recommended for mercury lamps where one burned out lamp leaves a rather large area in relative darkness. Other modifications of the above methods are known, but most plans fit into one of the three categories. Table II compares these three methods from the point of view of convenience and results, without regard to costs.

TABLE II — Comparison of Relamping Plans.

	Random	Retirement	Group
Need to keep records or take measurements.	No record necessary. (Replace lamps when burnouts occur.)	a) Card record necessary for each lamp or b) periodic measurement of light output made for individual lamps.	Little or no record necessary. Best plan* is to group relamp according to number of hrs. lamps have burned since previous relamping or on a calendar basis if burning schedule is fairly uniform.
Uniformity of light output.	Poor.	Generally good.	Generally excellent.
Maintained footcandle level.	Very much lower than initial.	Better than "Random," but generally not as good as "Group."	As close to initial as planned. Better than "Random."
Tie-in with periodic washing program.	Poor.	Fair.	Excellent.

*An alternate procedure would be to group relamp when photometric measurements indicate that average lamp lumen maintenance has fallen below the planned minimum value, but this system depends largely on the number of lamps photometered and the accuracy of the measurements. It will usually prove expensive.

Another procedure for timing relamping cycle would be to set aside a stock of spare lamps to replace early burnouts and to group relamp when they are all used up, but this system depends entirely on lamp mortality and may result in wide departures from the optimum relamping cycle particulary in small installations where there can be appreciable variation from average mortality. The calendar system minimizes this possibility.

From Table II it can be seen that group replacement would give the best results at maximum convenience but that the retirement plan might be worth considering if it had enough advantage in overall costs. Before studying these plans in more detail, let us examine the characteristics of mercury lamps having a bearing on the problem.

Factors That Influence Mortality And Lumen Depreciation

Mortality and lumen maintenance characteristics vary somewhat among individual types of mercury lamps but there is enough similarity so that generalizations may be made based on the study of only one or two types. Data are not easily obtained because no equivalent forced-life test is known for mercury lamps as for incandescent lamps. Then also, the design of the lamps has been changing so rapidly through improvements[4] that data being accumulated are often obsolete when finally tabulated. The curves used in this paper for cost analysis are limited to the type for which the most information is available. We have taken the popular 400-watt E-H1 (quartz arc tube) mercury lamp as the principal example.

The 400-watt J-H1 fluorescent-mercury lamp is identical to the E-H1 except for the addition of a magnesium fluorogermanate phosphor coating.[4] It has the same mortality curve as the E-H1 and a very similar maintenance curve. Other quartz types such as the 250-watt C-H5 (mercury) and D-H5 (fluorescent mercury), the 700-watt A-H18 and B-H18, and the 1000-watt types are near enuough in design and performance to be considered essentially similar. The A-H1 and A-H9 lamps with glass arc tubes have important differences and should be investigated separately for more exact determination of the optimum relamping plan.

Mortality and lumen depreciation are determined to a large extent by the quality built into the lamps during manufacture. They are also affected by the way they are operated. Operating factors to be considered are: the cycle (burning hours per start), the ballast, supply voltage or current regulation, and the fixture. Burning position is not a factor for lamps with quartz arc tubes except that light output is reduced roughly two to four per cent in horizontal operation as compared with vertical, but percentage-wise lumen maintenance is the same.

From a practical viewpoint, differences in operating cycle affect mortality and lumen maintenance

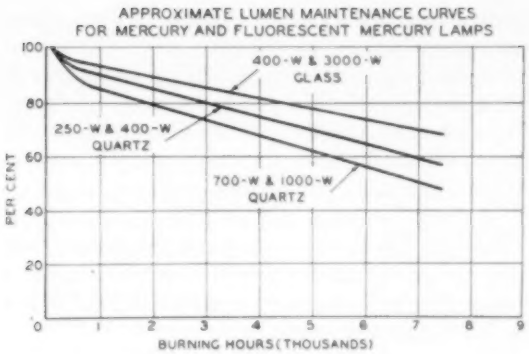


Figure 1.

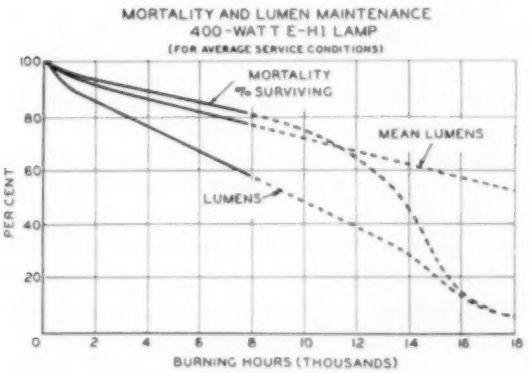


Figure 2.

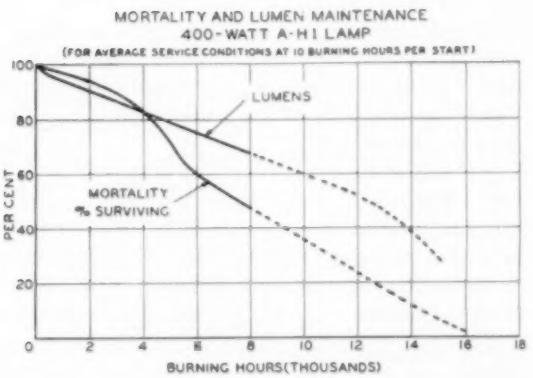


Figure 3.

very little in quartz lamps. Laboratory tests have indicated no difference in mortality for lamps burned either five or eleven hours per start, and lumen maintenance is the same after the first 500 to 800 burning hours. For lamps with glass arc tubes, like the A-H1, there is a distinct difference in the shape of the mortality and lumen maintenance curves according to operating schedule, so published values always specify the particular cycle which applies.

The ballast used can have a marked effect on both lamp life and lumen output.[5] The following are the most desirable features of a good ballast:

1. Adequate starting voltage and adequate well-regulated starting.
2. The right operating current; hence the right wattage.
3. A favorable current wave-shape; present indications are that the current crest factor (ratio of peak to RMS current) should be satisfactory up to at least 1.85.
4. A sufficient number of taps (unless constant wattage or series type) to permit proper operation.
5. Proper design to allow for minor manufacturing variations in lamps.

Poor control of supply voltage, or poor regulation of current in series installations, may lead to overcurrent (overwattage). Improper selection of a ballast tap may have the same result. Overwattage apparently has an exponential effect on lamp life and lumen maintenance. At less than 10 per cent overwattage, lamp life and lumens are so little affected as to be unnoticeably different from normal. Above this point there will be progressively shorter life and more rapid lamp blackening. Underwattage is less critically important but also undesirable and frequently detrimental.

The type of fixture used may also be a factor which influences lamp life and lumen maintenance. The fixture may overheat the outer bulb, may redirect light through the arc tube, or may have certain physical disadvantages. Some fixtures have been known to scratch the bulbs. Although minute at first, the scratch may slowly grow into a glass crack and bring about ultimate failure. Other fixtures are supposed to protect the bulbs from the elements or from rain coming in open windows — but if they fail to do so, cracks will occur whenever water strikes a hot bulb (except for waterproof hard glass lamps). The bulb may continue to burn for 300 to 1000 hours but will fail earlier than it would otherwise have done.

Mortality and Lumen Maintenance Curves

The mortality and lumen maintenance curves shown in Figs. 1, 2 and 3 are average curves and are derived for the most part from data obtained from tests of large numbers of lamps under well-regulated laboratory operation, with the addition of a safety factor which makes them practical for actual service installations. The curves are dotted beyond 8000 hours to indicate less degree of reliability, because of limited data. Individual lamps and installations may have departures from the values given in view of the factors previously mentioned, as well as because of minor variations in product.

Where large numbers of lamps are operated, these minor variations generally balance out. A large manufacturing concern in Flint, Michigan, estimates that no more than 10 per cent of their J-H1 lamps have burned out after approximately 6500 hours' operation. Fig. 2 predicts 16 per cent out at this point (for E-H1, but J-H1 is almost identical). Similar excellent performance is reported by many others, but there are enough field data to indicate that the overall results through the years are not too different from the curve shown.

Similarly, we believe the lumen maintenance curves are fairly well borne out in actual service experience. A number of photometric tests have been conducted on old lamps selected from customer installations and reasonably close agreement has been found.

Basic Economic Considerations

The lamp maintenance problem is essentially the same as a machine maintenance problem. In both cases it is most desirable to have constant output at maximum efficiency and to practice preventive maintenance in order to obtain optimum economy of operation.

In the field of lighting, costs are generally measured in terms of the amount of light received. One measuring stick is the familiar "Cost of Light" Analysis. By calculating costs for various times of relamping it is possible to demonstrate that for any given set of conditions there is one particular time when *cost of light* is lowest. While this method of analysis may be considered the proper way of resolving the problem of when to relamp, it does not result in *minimum relamping cost*. Actually, the longer the relamping cycle, the less money is spent on lamps and labor. The longest possible cycle results in random relamping and greatest savings in lamps and labor. However, lamps and labor are not the only costs involved.

This paper will assume that to many people actual savings are more important than the extra light that would be obtained by replacing lamps before they burn out (despite the fact that the only reason the fixtures were bought in the first place was to get light). It will assume, however, that no one wishes to spend money (on investment and power) which produces no return. In other words, this paper will consider that money saved at the expense of lower efficiency is a false saving. When money is saved by postponing relamping, some money spent for power and investment amortization is wasted. The *net* money saved then becomes the difference between money saved and money wasted. *Minimum cost of relamping* results when the *net* savings are maximum.

What *is* the cost of relamping? Obviously, it costs money for lamps and labor when lamps are replaced. Less obviously, it also costs money when lamps are *not* replaced. This hidden expense occurs because the efficiency (lumens per watt) of a mercury lamp decreases continuously throughout its life. Loss in efficiency represents an indirect cost due to *wasted energy and investment* because a lesser return is obtained for the same fixed power and investment expense.

It is thus possible to define Total Relamping Cost as follows:

Total Relamping Cost = Direct Relamping Cost + Indirect Relamping Costs + Intangible Costs.

Direct Relamping Cost = Cost of Lamps + Cost of Labor to replace lamps.

Indirect Relamping Cost = Cost of Wasted Energy + Cost of Wasted Installation.

Intangible Costs = Costs that may result from doing without the advantages of well maintained lighting.

The indirect relamping costs are a relatively new concept and bear further explanation.

The cost of wasted energy is *that* energy actually paid for but from which nothing is obtained. As a mercury lamp burns, it gives progressively less light per watt. Since its wattage remains practically unchanged throughout life, the result is that each unit of light becomes progressively more expensive or that part of the *energy that is actually paid for is wasted.*

The cost of installation wasted is derived as follows. The *only* reason lighting equipment, wiring, etc. are installed is to provide light. If *more light* is wanted, more equipment is installed; if *less light* is wanted less equipment is installed. For a given level of illumination, more, or less, equipment must be installed depending on the way lamps are maintained. In any case, *once a certain amount of equipment is installed,* it is depreciated over a period of time whether it is used or not. If lighting equipment is installed and *no light* is *ever* obtained from it, the whole investment is wasted and the yearly waste would equal the cost of amortization.

The *cost of wasted installation* is therefore that fraction of the amortized installation costs (depreciation, taxes, interest) *from which no light is obtained* due to lamp depreciation. (A similar fraction is wasted due to dust and dirt but that is not considered here since it falls into the category of cleaning costs rather than relamping costs).

Because they cannot be assigned an *exact* dollar value, intangible costs are omitted from calculations in this study. They *always* tend to favor planned relamping. They include the costs that may result from doing without such advantages of well maintained lighting as:

Improved seeing conditions resulting in —
- Less accidents.
- Higher productivity.
- Less spoilage and defects in workmanship.
- Better worker morale.

Value of good impression created by uniform appearance.

Fewer interruptions in work by employees, supervisors, etc.
- Investigating to see if lamp is "really" out.
- Putting through request for replacement.
- Handling request.
- Time lost by those working under lamps replaced.
- Time lost by curious and helpful "neighbors."

Less time lost by idle machines.

Lower cost of maintaining auxiliary equipment.

The basic thought behind all lamp replacement programs is the question: Will increasing some costs such as lamp costs create enough reduction in other costs to result in a lower Total Relamping Cost? This thought can be reworded into the practical question. Will putting a lamp replacement plan into effect save me *money* and, if so, after how many burning hours should I replace "good" lamps?

The answer lies in a Relamping Cost Analysis.

Relamping Cost Analyses

Now that the general make-up of the Total Relamping Cost has been defined, on what do these various costs depend?

Lamp Cost depends on —
- Lamp mortality.
- Net cost of new lamps.
- Cost of purchasing.
- Cost of warehousing or storage.

Whether costs are or are not assigned to the functions of purchasing and storing it is obvious that both functions are performed and include both personnel and space — neither of which is "really free" but might form part of a hidden "overhead" expense. In either case, an exact analysis should include these expenses.

Labor cost per lamp depends on —
- Labor rate (including overhead charges).
- Time to replace lamp.

The labor rate is fairly constant for a given installation but the relamping time is subject to many variations, chiefly that when many lamps are replaced at once (group replacement) it takes less time than when lamps are replaced one at a time. The ratio may be as great as 10 to 1 or more. Usually it is about 5 to 1.

Cost of energy wasted depends on —
- Mean lumen depreciation.
- Energy rate
- Watts per lamp (including ballast and line losses).

The lumen depreciation depends on how long lamps are allowed to burn before being replaced.

Cost of installation wasted depends on —
- Mean lumen depreciation.
- Total burning time.
- Rate of investment amortization, including interest and taxes.
- Time — While this is not a cost in itself, it affects all costs because both mortality and lumen depreciation take place in *time*.

The actual procedure for calculating the costs of random *vs* group relamping (using new lamps) can be tabulated into a work sheet as shown in Table III. Lines 1 through 3 have been precalculated using average data. Line 1 and particularly line 3 may vary between locations due to local conditions. Using similar work sheets for the other replacement plans, it is possible to compare their relative economic merits.

With such work sheets, the lowest cost plan can be determined for any set of conditions. The numerical data thus obtained are valuable evidence in selling management the advantages of adopting administrative procedures to put the best plan into effect. It should be mentioned at this point that results obtained by the above method indicate optimum relamping cycles that are slightly longer than those obtained by a cost of light analysis. For example, in Fig. 4, Case A, the optimum relamping cycle by the relamping cost analysis is 7500 hours, but by a cost of light analysis it would be 6000 hours. The reason for this difference has previously been explained: the shorter cycle is the point of maximum light per dollar and the longer cycle is the point of minimum net dollars spent.

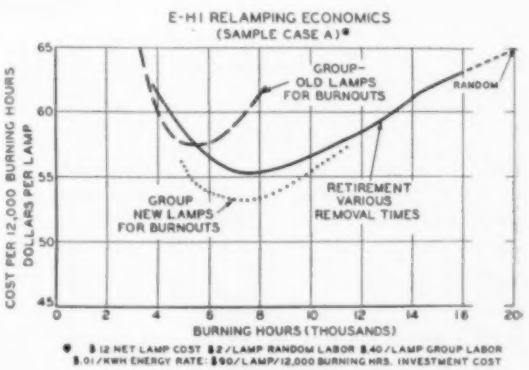
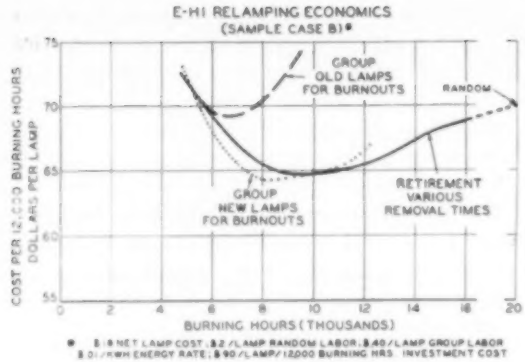
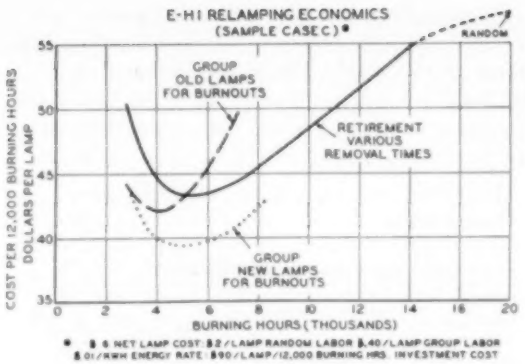
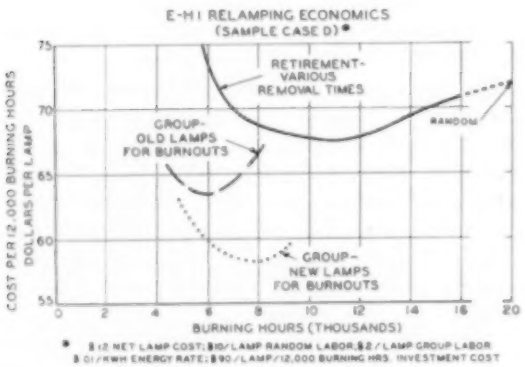
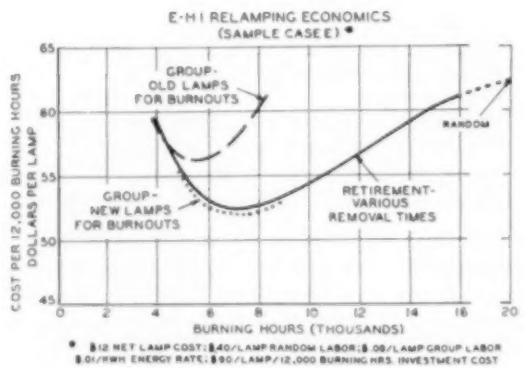


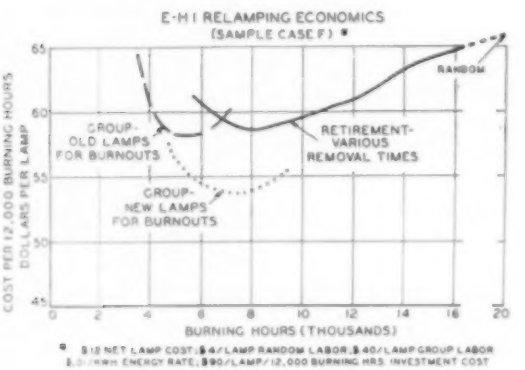
Figure 4-A.

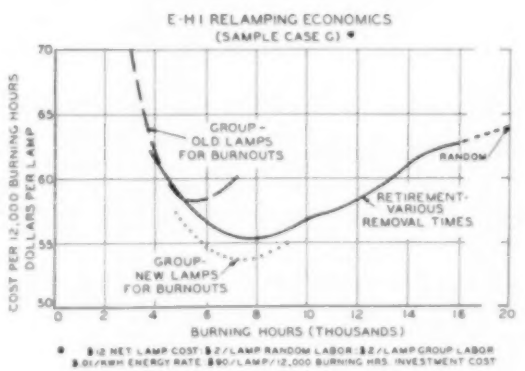




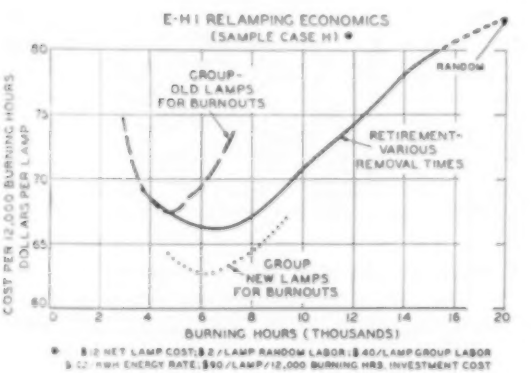


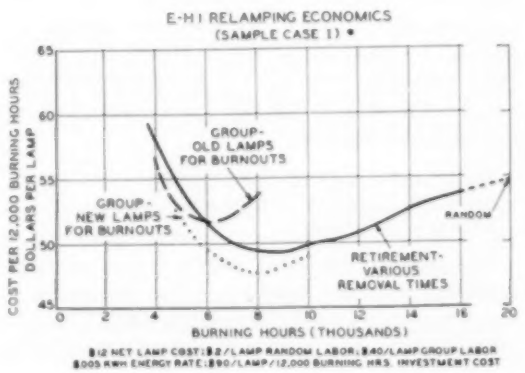


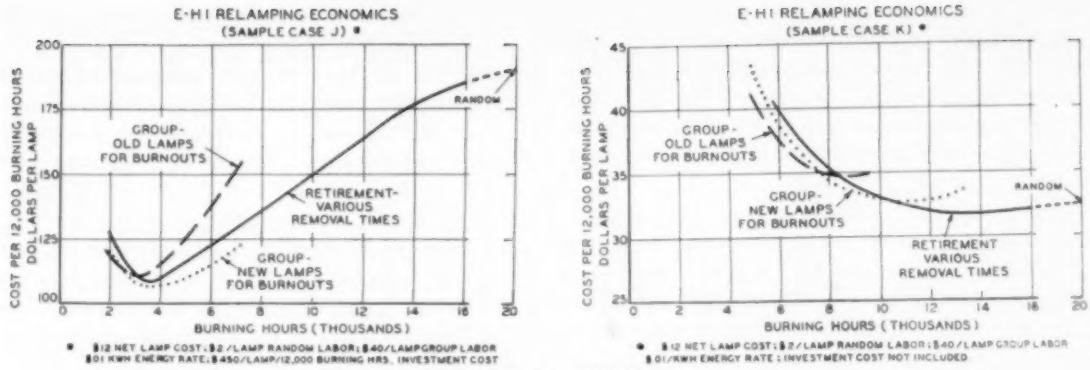




Figures 4-B to 4-I.







Figures 4-J and 4-K.

Figs. 4A through 4K give the results of sample cases showing variations of Total Relamping Cost with time for the three major relamping plans outlined in Table II, under several assumed conditions. In calculating Total Relamping Cost for the Retirement Plan, no additional cost was assigned for keeping records, etc.

The Group Replacement plan is considered using both new lamps and old (saved from a previous cycle) lamps to replace early burnouts between group replacement cycles. In practice, group replacement plans should be considered only when all lamps in the group burn approximately the same number of hours per month. Because very few existing installations will have exactly the conditions assumed, care should be exercised in interpreting the results. Nevertheless, some general relationships are apparent. In the majority of cases, a group relamping plan using *new lamps* to replace early burnouts is most economical.

The most economical cycle for group relamping using "old" lamps to replace early burnouts is always shorter than that for group relamping using new lamps. It is also more expensive. Likewise a retirement plan always seems to have a cycle as long or longer than any other plan.

Random relamping is nearly always the most expensive way of relamping, and always more expen-

TABLE III — Group Relamping Work Sheet for E-H1 Lamps.
(Using New Lamps to Replace Burnouts)

	GROUP RELAMPING CYCLE (BURNING HOURS)	5000	6000	7000	8000	9000	10000	12000*
BASIC DATA	1. Mean Lumen Depreciation of Installation	.15	.17	.19	.21	.23	.25	.28
	2. Correction Factor for Length of Cycle $\frac{\text{(Random Life)}}{\text{(Group Life)}}$	2.4	2	1.715	1.5	1.33	1.2	1
	3. Number of Replacements Needed for Burnouts (per hundred lamps)	14	17	20	22	26	29	41
SPECIFIC DATA	4. Net Lamp Cost ($)							
	5. Number of Lamps in Installation							
	6. Average Lamp Life* for Installation (hours)							
	7. Labor Rate per hour, including overhead ($)							
	8. Time to Random Relamp (minutes per lamp)							
	9. Time to Group Relamp (minutes per lamp)							
	10. Energy Rate ($ per KWH)							
	11. Watts per Lamp (including ballast loss)							
	12. Total Cost of Installation (Luminaires + Wiring + Labor + Interest + Taxes)							
	13. Amortization Period (in months)							
	14. Burning Hours per month							
RANDOM RELAMPING COST	15. Cost of Lamps for Random Relamping (4×5)							
	16. Cost of Labor for Random Relamping (5×7×8÷60)							
	17. Cost of Energy Wasted (1*×5×6×10×11÷1000)							
	18. Cost of Installation Wasted (1*×6×12)÷(13×14)							
	19. Total Cost of Random Relamping (15+16+17+18)							
GROUP RELAMPING COST	20. Cost of Lamps for Group Relamping (2×4×5)							
	21. Cost of Labor for Group Relamping (2×5×7×9÷60)							
	22. Cost of Lamps for Relamping Burnouts (2×3×4×5÷100)							
	23. Cost of Labor for Relamping Burnouts (2×3×5×7×8÷6000)							
	24. Cost of Energy Wasted (1×5×6×10×11÷1000)							
	25. Cost of Installation Wasted (1×6×12)÷(13×14)							
	26. Total Cost of Group Relamping (20+21+22+23+24+25)							
	27. Savings of Group Relamping (19−26)							

*Basic data given for 12,000 burning hours per relamping cycle. This actually corresponds to 10,250 hours average lamp life. For Random Relamping the average lamp life is 12,000 hours for which lumen depreciation of .35 should be used.

sive than retirement. Only when lamp costs are very high and labor, energy and amortization costs very low does random relamping begin to compete in economy. Even in such cases, other benefits of planned relamping such as co-ordinating relamping with cleaning, if considered, will prove the greater economy of a plan.

Since the most economic group relamping time may vary from 3000 to 13,000 burning hours it is not possible to recommend any one time or a narrow range of time in which group relamping will be best in all installations. However, relamping at the proper time is most important if maximum economy is the goal.

The effect of varying conditions is plotted in Fig. 5 and tabulated in Table IV, showing the following general characteristics:

Lamp Cost — The lamp cost has considerable influence both on Total Relamping Cost and on the optimum length of relamping cycle. In case C, Figs. 4 and 5, the net lamp price used ($6) was chosen arbitrarily to show a trend and does not represent an existing price. A higher lamp cost increases the Total Relamping Cost and makes the optimum relamping cycle longer.

Labor Rate — The labor cost has very little influence on either Total Relamping Cost or on the optimum length of relamping cycle.

Labor Cost Ratio — The ratio between the cost of relamping individually or by groups may vary from one-to-one to ten-to-one with practically no influence on either Total Relamping Cost or on the optimum length of relamping cycle.

Energy Rate — The cost of energy also has considerable effect on both Total Relamping Cost and optimum length of relamping cycle. A higher energy rate results in a greater Total Relamping Cost and in a shorter optimum relamping cycle.

Investment Cost — The cost of the investment wasted is directly related to the total burning hours per year as well as to total amount of investment, length of period of amortization, interest charges, etc. Any change that increases the fixed charges results in increasing relamping costs and in shortening the optimum relamping cycle.

Time is the dependent variable that changes with practically every change in costs.

Other Factors Influencing a Relamping Policy

After calculating the most economic plan for relamping for a given set of conditions, there are other factors that should be considered such as:

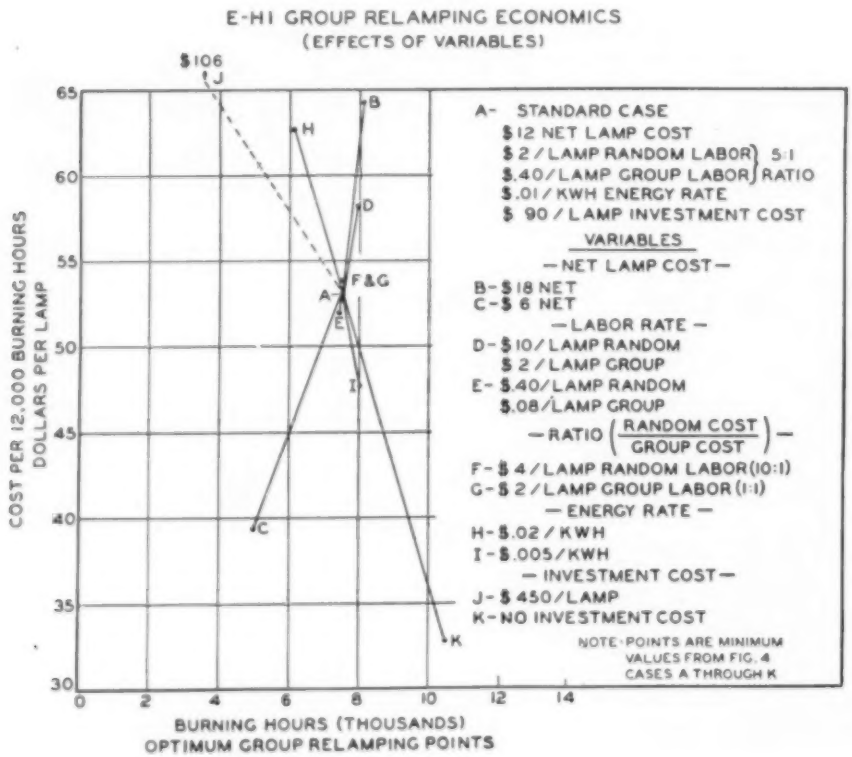


Figure 5.

TABLE IV — Sample Case Comparison.

Case*	COSTS					TOTAL RELAMPING COST per lamp per 12000 hours			OPTIMUM RELAMPING CYCLE	
	Lamp (Net)	Random Labor	Group Labor	Energy (per KWH)	Investment (per lamp) 12000 hrs.	Group**	Retirement	Random	Group** (Hours)	Retirement (Hours)
A	$12	$2	$.40	$.01	$90	$53.10	$55.25	$64.00	7500	7500+
B	$18†	$2	$.40	$.01	$90	$64.15	$64.70	$70.00	8000	9000
C	$6†	$2	$.40	$.01	$90	$39.45	$43.30	$58.00	5000	5000+
D	$12	$10†	$2†	$.01	$90	$58.25	$67.50	$72.00	8000−	11000
E	$12	$.40†	$.08†	$.01	$90	$52.05	$52.45	$62.40	7500−	7500
F	$12	$4†	$.40	$.01	$90	$53.75	$58.65	$66.00	7500	8000
G	$12	$2	$2†	$.01	$90	$53.75	$55.25	$64.00	7500	7500+
H	$12	$2	$.40	$.02†	$90	$62.85	$66.10	$82.45	6000+	6500
I	$12	$2	$.40	$.005†	$90	$47.65	$49.35	$54.75	8000	9000
J	$12	$2	$.40	$.01	$450†	$107.00	$110.00	$190.00	3500	3500
K	$12	$2	$.40	$.01	——†	$32.70	$31.80	$32.50	10500	13000

*Refer to Sample Case curves.
**Using new lamps to replace burnouts between relamping cycles.
†Variable in case.

Shutdowns or vacation times.
Minimum lighting level acceptable for task.
Availability of equipment needed for relamping.
Manpower to do the work.
Training of an organized crew.
Necessity for, or advantages of, investing in special equipment.
Coordination with cleaning program (relamping costs are more sensitive than cleaning costs to the time interval).

Thus, in a given plant the best group relamping cycle may calculate to be 7500 hours but if the burning hours per year are 4000 and the plant shuts down for vacations two weeks every summer, it will undoubtedly pay to extend the cycle to 8000 hours so that group relamping may be done during shutdown every other year. On the other hand, extending the cycle to 8000 hours will result in a drop of about 40 per cent in light due to lumen depreciation. This may result in poor illumination and necessitate a shorter cycle.

Determination of Useful Lamp Life

"Useful" lamp life is most economical lamp life. Degrees of usefulness exist, but for practical purposes a lamp may be considered to have outlived its usefulness when it costs more money to keep it burning than to replace it. This concept of "useful life" is distinctly different from "actual average life," which is much longer, and generally different from "rated average life." In rating mercury lamps, manufacturers have been conservative[2] and have generally kept ratings even lower than would be justified by "useful life."

As an example, the E-H1 has an actual average life of approximately 12 000 hours, a rated average life of 6,000, and a useful life (not average) that is generally from 6000 to 10,000 hours, but may be as low as 3000 or as high as 13,000.

Useful life is a variable quantity, since it depends on balancing the cost of relamping against the cost involved in not relamping. Therefore, it will vary with all the cost factors. Another definition of useful life would be maximum lamp life for the least money.

Referring to the various cases of the cost analyses, useful lamp life is the point at which it costs the least to relamp. Case A (Figs. 4 and 5) has been chosen as most typical for both industrial and street lighting installation, but because of the generally higher investment cost for street lighting, the optimum relamping cycle will often be less than 7500 hours.

In the cost analyses, lamp data are for the E-H1. For other mercury type lamps a generalization may be made that useful life will be not too different from that of the E-H1. That is because:

1. Mortality and maintenance are not too different.
2. Lamp price and total investment costs tend to offset each other. That is, in general, a high price lamp will have a high per lamp investment cost (ballast, fixture, wiring, etc.). The higher lamp cost tends to lengthen the optimum relamping period, while the higher investment cost tends to shorten it. For lower price lamps, the opposite applies.
3. Energy rate does not vary according to lamp type, and so is not a factor for comparing one type lamp with another.
4. The labor rate and the labor ratio (cost of random vs. systematic replacement) are not governing factors, as previously pointed out, so also do not affect the comparison.

Conclusion

What then is the answer to the question — does group replacement of mercury lamps pay and, if so, why time cycle is most economical?

The answer to the first part is that in practically all cases some kind of *systematic* relamping plan will be cheaper than random relamping. In most cases group replacement using new lamps to replace early burnouts will be the best plan to use.

The answer to the second part is that the optimum time depends on too many variables for a

"pat" general answer. The thing to do is to calculate the economics of each case. Table III is designed to make this calculation as simple as possible.

While the above conclusions are all based on Total Relamping Cost Analyses of the E-H1 lamp, extrapolation of the data will cover other mercury lamps having nearly similar mortality and lumen depreciation characteristics.

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DISCUSSION

WAYNE H. JOHNSON:* I note that Fig. 2 of this paper includes a mean lumen curve. However, there is no explanation of how this mean lumen curve is derived, and I wonder if the authors would provide one.

F. D. WYATT:** The authors have performed a very necessary job in making the analysis presented in this paper.

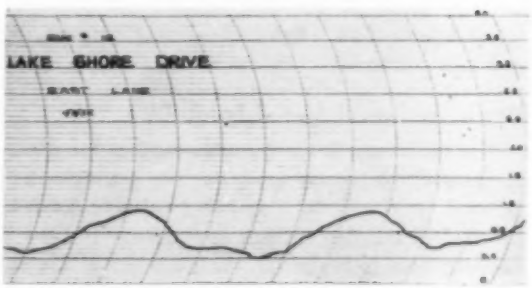
For the past ten or fifteen years, the manufacturers and users of mercury lamps have been mainly interested in increasing the life of the lamps. It appears now that the manufacturers have made large improvements in the design of mercury lamps so that detailed refined analysis can now be made to determine the length of usage, and the life, and lumen output of mercury lamps which would give the least overall cost for light.

In 1946 and 1947, we were fortunate to get an average of 3,000 hours in E-H1 lamps used for street lighting. Now, with the accumulated improvements in design there seems to be no question that a life span of 6,000 hours can be secured in the same lamp in street lighting service. The interest of the user in checking mercury lamps now will shift from the question of life expectancy to the question of lumen maintenance throughout the life of the lamp.

The cost analysis presented in this paper will be most useful, particularly for indoor installation. Due to the high cost of the lamps, which is around $11 for the E-H1, and the high prevailing cost for maintenance, there is some question whether group replacement is feasible for the street lighting systems. In order to reduce the frequency of cleaning and to allow for depreciation in lumen output of the lamp, we have found it desirable to design street lighting installations for a total lumen maintenance value overall for luminaires, glassware and lamps of 65 per cent. This, of course adds to the purchase cost for the lighting installation, but appreciably reduces the maintenance cost. As a safeguard to assure that the lumen maintenance value is not decreased below 65 per cent, we propose the use of a test car on which is mounted light cells, with a power multiplier and a chart which will show the value of light falling on the pavement in a given traffic lane. This chart is driven by a speedometer chain connected to the rear wheel and therefore measures linear distances along the roadway. The equipment on a car represents about $1,200 in investment cost. Two men can operate the car at a speed of fifteen miles per hour and secure a chart record of the light level in a lane of traffic. Assuming that the labor cost, including overhead, is $4 per man-hour and that the car cost is ten cents per mile to operate, in a four-hour shift, two men can make a chart record of approximately twenty miles per street on both sides. This represents a unit cost of approximately $2 per mile of highway. The

Test car.

Equipment in car.



Record on chart.

*Electrical Engineering Div., American Gas and Electric Service Corp., New York, N. Y.
**Street Lighting Consulting Engineer, 1435 Catalpa Ave., Chicago, Ill.

charts will identify any individual lamppost on which the light level is below the pre-determined minimum acceptable value. This reading, of course, will show any trouble with luminaires, such as poor reflectors, or dirty glassware or misalignment, as well as low light output lamps.

It is suggested that if this record is taken at three- or four-month intervals and followed up the following day with replacement of low-life, output lamps, that the maintenance costs for the street lighting system will be secured.

JOHN W. YOUNG:* The authors are to be complimented for their presentation of the subject of relamping mercury lamps. Many users have been looking for just such material as is given in the paper. It should stimulate interest by users in analyzing their lamp performance and thereby arrive at some systematic method of relamping. Such method aside from the solution of lamp burning calculations and costs should include consideration of operating factors as luminaire cleaning and maintenance, to realize optimum lamp performance.

Lamp life and lumen maintenance are co-factors in any solution. In street lighting service, lamp life has passed the stage of burning lamps to failure in order to obtain the rated average life of groups of lamps. The industry now has considerable knowledge of lamp life in field service. The authors' data are taken as covering all types of applications (in which indoor applications are in the great majority) and that the most economic group relamping time may vary from 3000 to 13,000 burning hours. In street lighting service on the systems with which the writer is connected, experience indicates a range of 6000 to 12,000 hours as a reasonable range. To date it appears that 8000 hours, or approximately two years in street lighting service as the probable economic period for the 400-watt and 250-watt lamp. A few groups have performed on an 8000-hour schedule since 1950.

The lumen maintenance curves as shown in Figs. 1, 2 and 3 are of particular interest to the application engineer since but a small amount of published data has been available. Understandably, representative performance data from the laboratory and field are bound to lag somewhat in view of the steady improvements forthcoming with a newer source as the mercury lamp ,and the various types of ballasts now in use. But, somewhere along the lumen maintenance line for a given type of lamp, the lamp has fulfilled its job as set up in the engineer's calculations and it should be removed. In lieu of exhaustive calculations a judgment figure of 35 per cent light output reduction, lamp and dirt factor, has been looked on as reasonable.

As to the mortality curve, several groups have been studied and the curves do not vary appreciably from those shown in Figs. 2 and 3, although the point where the knee occurs sometimes varies widely; as, for example, considerably beyond the 6000-hour average rated life. The authors may be able to produce more data in time on this point.

The E-1 lamp, it has been noted, after a few early burnouts follows a straight line (gradually dropping, of course) for long burning periods.

Our experience confirms the statement that group replacement provides excellent uniformity of illumination. Group relamping in heavy traffic areas is more efficient than random or frequent replacement of small groups of lamps. Avoiding the inconvenience and hazards of heavy traffic is highly desirable. From our calculations, globe washing should be included with the relamping trip.

*New England Power Service Co., Boston, Mass.

D. R. PHILLIPS:* There is a rapidly growing realization of the importance of "economic life" as distinguished from the actual length of time the lamps will operate before failure. The authors' discussion is timely and will be of interest to those responsible for maintenance of lighting systems.

The impression is obtained that under the heading of Basic Economic Considerations on page 280 the authors are determining the minimum relamping cost by considering only the money which is spent by the customer. This assumes that any decrease in mean illumination level is not important to the user of a lighting system. Thus, it should not be given a dollar value. The authors point out that this is different from a "cost of light" analysis which *does* put a dollar value on the wasted investment and energy costs in their "relamping cost" analysis. Is not this the same as saying the increase in light should be given credit? The authors rationalize this by stating that these are costs which are "actually paid for but from which nothing is obtained." Doesn't depreciation in light output result in wasted lamp and labor costs as well as wasted investment and energy costs?

It should be stated clearly that "minimum relamping cost" has no correlation with "minimum cost of light." In addition, the differences between "total relamping costs" of various systems compared by the method the authors propose (which multiplies costs by a depreciation factor) may be unrealistic because of the possibility of distorting costs.

It is obviously good practice that any method used to calculate costs must be consistent as to the items it includes. This means that if wasted costs are used as a guide to relamping programs they have to be applied to lamps and labor as well as to investment and energy. If it is a "relamping cost" analysis then only charges for lamps and labor should be included. It seems incongruous to combine wasted cost items determined on a cost of light basis with those items for relamping, which do not take into account differences in light output, to arrive at a "total relamping cost." Such results are extremely difficult to rationalize.

Perhaps the foregoing is the reason that the authors' data show in most cases a much higher "total relamping cost" where old lamps are used for replacing burnouts than where new lamps are used for replacing burnouts. Can the authors justify this difference without going to the commonly used cost of light method? Isn't the apparent improvement in economy shown by the authors due to differences in maintained light output of the two systems?

The authors indicate that Table III is designed to make calculations of costs by their method as simple as possible. This is greatly facilitated if one is familiar with the authors' method to begin with. It would be helpful in creating a better understanding of the method if figures had been included in some of the columns of Table III permitting correlation with the figures of Table IV.

In Table IV the authors list the investment per lamp per 12,000 hours. Assuming that the lighting system is used 4,000 hours per year (typical of two-shift operation), and that the amortization, insurance and taxes amount to 15 per cent per year, the total investment cost per lamp for cases A through I is $200. Do the authors feel this is a typical figure? From my experience this seems high.

Part of the paper is devoted to comments on lamp characteristics. It appears that some of the broad generalizations on lamp characteristics included in the paper tend to group together lamps which are sufficiently different so

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that the conclusions may be altered. The authors point out that quartz arc tube lamps such as the 250-, 700- and 1000-watt types are near enough in design and performance to the H400-E1 lamp to be considered essentially similar. This is at variance with experience indicating that the 1000-watt mercury lamps have significantly lower lumen maintenance than the H400-E1.

It is also stated that "burning position is not a factor for lamps with quartz arc tubes except that light output is reduced roughly 2 to 4 per cent in horizontal operation as compared with vertical, but percentage-wise lumen maintenance is the same." This loss in initial output is about what we would expect if the lamp is operated at rated wattage in horizontal position. However, slightly better lumen maintenance might be expected. Also, on the same ballast, the lamp operated horizontally consumes less wattage with resultant reduction in light output somewhat greater than the authors show.

I agree with the authors that "minimum relamping cost" does not always occur with minimum "cost of light." The authors are to be commended if their purpose is to strike a compromise between these two costs. However, it should be recognized that any method which attempts to accomplish this is, at best, an arbitrary one.

W. S. Till and M. E. Haskins, Jr.:* We wish to thank Mr. Johnson for pointing out an important omission in the paper. The reason for the omission was to cut down the length of the paper by not showing or explaining all the calculations involved.

Specifically, the mean lumen curve is the integral of the lumen curve. At any one point, say 8000 hours, the lumen output of all lamps surviving is 57 per cent of initial as shown by the *lumen* curve while the *mean lumens* of all lamps surviving is 76 per cent of initial. This means that the total lumen hours of lamps that burn 8000 hours is the same whether the lamps start at 100 per cent lumens and go to 57 per cent lumens as shown in the lumen curve or whether they had started at 76 per cent of initial lumens and continued at that value for the entire 8000 hours.

In working out any specific case, the relamping policy is an important factor in determining installation lumens. The most economic plan in the majority of cases is to use new lamps to replace burnouts between group relamping cycles. The most economic cycle for a particular job can be quickly calculated using Table III in the paper. Line 1 in the table is precalculated to yield the mean lumen depreciation of the *installation* at various hours where burnouts are replaced with new lamps. The mean lumen values for the installation are higher than those read from the mean lumen curve because they include the output of replacement lamps while the published mean lumen curve applies only to lamps surviving.

We wish to thank Mr. Wyatt for his constructive comments based on long experience with mercury lamps in street lighting service. The method of relamping he proposes is a form of the retirement plan described in our paper, since lamps are replaced individually when footcandle readings show less than a predetermined light output value from the fixture.

The photometric type of method can also be used to decide the best time for group replacement. The advantages of group replacement are that practically no time need be taken to interpret the chart, check fixtures, or decide exactly which lamps should be replaced. Photometric measurements become less important and hence need be made only at rare intervals, because all lamps start out new at each replacement and therefore require less frequent inspection. With group replacement light output is more uniform from lamp to lamp. Also the cost of changing lamps is lowest, since more lamps can be changed at one time. Cases J and D of the charts given in our cost studies are probably most applicable to street lighting, in principle, although representing extremes. Both show a marked advantage for group replacement, and we therefore believe that if a similar chart were marked out for the conditions actually prevailing in Mr. Wyatt's installations it would also favor group replacement.

We wish to commend Mr. Wyatt for investigating the problem of removing old dim mercury lamps, and while we do not agree that his solution is the best, we think that it is far better than waiting for the lamps to burn out.

The authors wish to thank Mr. Young for his comments with which we are in complete agreement.

It is gratifying to see the thorough study Mr. Phillips has made of our paper. We regret that he finds so much with which to disagree but believe there would be little disagreement if he interpreted the section "Basic Economic Considerations" as we intended.

The third paragraph of that section explains that the paper will consider both the money spent by the customer (sentence 1) and the efficiency (light per dollar) factor (sentence 3), which includes evaluation of the mean illumination level. The authors do not intend to minimize the importance of good illumination but do consider that there are circumstances where a *small* decrease in illumination can be justified to effect *real* savings in dollars. This has long been realized intuitively by many practical users (to whom 50 footcandles are not always worth *twice* as much as 25) and is probably the main reason why more installations are not using group relamping programs. The authors' method answers the question, "How much money can *really* be saved at the expense of a small reduction in light?"

When many practical persons consider the need for relamping and are shown a "cost of light" analysis of the problem, they will usualy say, "Sure, the cost of light analysis shows I pay less *per lumen* if I relamp at say 6000 hours, but to me the extra lumens per dollar are not worth the *extra dollars* that I must spend for lamps and labor." Following the logic of such a set of values, the least cost in lamps and labor occurs when lamps are not replaced until they burn out. Fortunately, most users also realize that the lighting level depreciates *too* much if they go to that extreme. Thus, it seems to them, there must be some practical point, between the *maximum light per dollar* point obtained by a "cost of light" analysis and the *minimum out-of-pocket cost*, at which an existing installation would be most economically relamped. For example, the way a "cost of light" analysis would present the conditions of Case A in the paper is given in Table D-I.

The "correct" conclusion is, of course, to relamp every 6000 hours; but the money-conscious manager is likely to bring up the set of figures shown in Table D-II.

These figures indicate that although relamping at intervals of 6000 will provide the most light per dollar spent, this maximum efficiency requires spending *more money* in *total* than relamping at longer intervals. Many users will wonder whether a $115 per year savings would not justify a loss of less than 3 per cent in light. In fact, they will not know how far to go in this "cost reduction" direction.

It is to resolve the above enigma in the minds of many practical men that the authors have introduced their "total

*Authors.

TABLE D-I — Cost of Light Analysis — Case A.
(Based on 100 lamps and 12,000 burning hours)

	Group Relamping at —— Hours					Random Relamping
	5000	6000	7000	7500	8000	
Total Cost (Lamps, Labor, Energy, Investment)	$17,727	$17,236	$16,890	$16,740	$16,602	$15,680
Relative Amount of Light	100	97.5	95	94	93	76
Relative Cost of Light	$177.3/L	$176.8/L	$177.8/L	$178/L	$179/L	$206/L

TABLE D-II.

	Group Relamping at —— Hours				Random Relamping
	6000	7000	7500	8000	
Dollars Saved: (relative to 6000 hours, from Table D-I)	——	$346	$496	$634	$1556
Dollars Saved per Year (4000 hrs/yr)	——	$115	$165	$211	$ 519

TABLE D-III — Total Cost of Relamping — Case A.
(Based on 100 lamps and 12,000 burning hours)

	Group Relamping at —— Burning Hours				Random Relamping
	6000	7000	7500	8000	
Dollars Wasted (see lines 24 and 25, Table III)	$2429	$2711	$2855	$3000	$4998
Dollars Wasted (relative to 6000 hrs)	——	$ 282	$ 426	$ 571	$2569
Dollars Saved (see Table D-II)	——	$ 346	$ 496	$ 634	$1556
Net Savings	——	$ 64	$ 66	$ 63	−$1013

cost of relamping" analysis. At any given time, the decision of whether to relamp or not to relamp hinges on weighing direct out-of-pocket costs of relamping against the indirect costs of *not* relamping. One of the three objectives of this paper is to show how to analyze these costs in order to obtain optimum economic results.

Thus, Case A is analyzed as in Table D-III.

The "correct" conclusion is now to relamp every 7500 hours. This means that although on a *per lumen* basis more will be spent for light, on a *dollar* basis maximum *real* economy is achieved.

Thus the authors' method does not put a value on light — directly. It does show how to determine the relamping cycle that effects maximum *net* savings. The results are expressed in terms more convincing to expense-conscious users than those of a "cost of light" analysis.

In regard to Mr. Phillips' question as to why depreciation in light output does not result in wasted lamp and labor costs (as well as wasted investment and energy costs), we would like to point out the difference in the *nature* of these items. Lamp and labor costs are lump-sum expenses whereas energy and amortization of investment costs are continuous expenses. With this difference in mind, how can depreciation in light output result in wasted lamp and labor costs which are *not* incurred? In fact, it is the lamp and labor costs *to be* incurred by relamping that must be balanced against the waste in energy and investment costs which *are* incurred if the installation is not relamped. Furthermore, how can any portion of the cost of a lamp be wasted by continuing to *use* it for a longer period of time? Indeed, some of the lamp cost is wasted when a lamp is *discarded* before it burns out — but that is not due to light depreciation. Nor is its nature the same as the wasted elements of energy and investment. It favors not relamping whereas energy and investment wasted favor relamping. This element of cost is included in our analysis (in line 2 of Table III) by correcting for the length of cycle or proportion of total lamp life used. The same is true of labor cost.

It was not our intention to establish a direct correlation between the "cost of light" and the "total relamping cost"

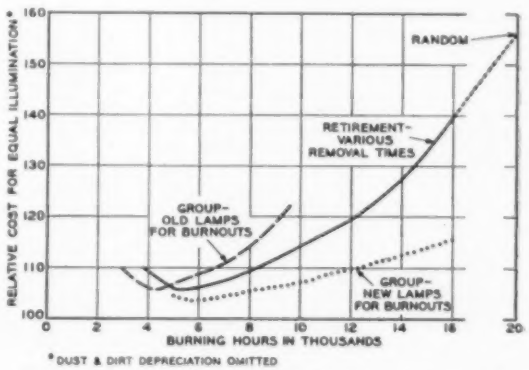


Figure D-1. E-H1 Cost of Light Analysis — Sample Case A.

methods. Nor should there be. The first, when applied to relamping cost study, answers the question, "What relamping cycle results in producing the most light per dollar?" The second answers the question, "What relamping cycle results in *minimum* net expense?" Yet, because the basic data used are the same for both, the results obtained with either method are similar, as can be seen by comparing Fig. D-1 with Fig. 4-A in the paper.

Regarding the inference that our method makes comparison of various systems unrealistic, we do not believe that Mr. Phillips has made his meaning clear. If he means that comparison of the data presented in Table IV in the paper is not meaningful, he should have indicated how that could be so. If he considers the *omission* of "wasted lamp and labor" costs as a distortion, we have indicated previously why their *inclusion* would have distorted the true nature of these expenses. If he means that a cost comparison between say fluorescent and mercury lighting systems should not use the "total relamping cost" *figures* directly, as obtained by our method, he is correct but not because the *figures* are distorted. The system presented analyzes costs in *existing* installations where the number of fixtures and

lamps is *constant* and the illumination can be varied to effect maximum *relamping* economy. In comparing various different systems of *proposed* lighting in order to decide which is the most economical to *install*, the illumination is kept *constant* and the number of fixtures and lamps is *varied*. However, the above does not invalidate the authors' method for *existing* installations. Our experience has been that more often than not lighting systems are selected for *installation* on one basis, and maintained in *operation* on another basis. In fact, the common practice in cost analysis comparisons of different systems is to use the *rated life* of lamps in determining lamp and labor costs of relamping and to disregard completely any cost complications that might arise if lamps are relamped in a group instead of at random. That could *also* be considered as distorting costs! Yet, the results thus obtained generally indicate the *relative cost* of different lighting systems which is really the important thing to know in deciding which system to select. It is *after* the selection has been made that a closer scrutiny is made of the figures to determine exact costs, and plans for reducing operating costs of the system chosen (such as adopting or improving a group relamping program) are considered. It is for this latter purpose that the "total relamping cost" analysis is most useful. Perhaps a comparison with a more familiar situation will help clarify the authors' point. If a person with limited funds is deciding whether he should fly or take a train on a trip, he considers the cost of meals in analyzing relative costs. It is *after* his decision on the form of transportation has been made and he has looked at the menu that he may decide to economize on the figure for cost of meals he had used in his cost analysis.

The authors believe that the method presented is consistent in every respect, and have devoted a considerable part of the paper to explaining exactly how each cost item is derived and used, and its relation to other items. As further proof of its consistency, we have developed identical methods of analyzing "total relamping costs" for incandescent and fluorescent as well as mercury lamps. The procedures are identical to Table III except for the Basic Data section which, of course, varies according to the source. As explained previously, there is no logical reason for considering that lamp or labor costs *not incurred* can be wasted. The element of waste exemplified by discarding lamps before their end of life is considered in line 2 of Table III. The same correction for length of cycle is applied to labor. Thus, all items of cost that apply are used in analyzing "total relamping costs." Regarding Mr. Phillips' insistence that "relamping costs" can include only charges for lamps and labor, he is certainly entitled to his opinion but, in analyzing our method, we do not believe he should try to apply his own definitions instead of those carefully established in the paper.

The data show that it costs more to use old mercury lamps for replacing burnouts. The same results are found by using a "cost of light" analysis as shown in Fig. D-1. Mr. Phillips is partly correct in saying that new lamps are more economic than old because of the difference in maintained light output. That is one of the bases of the "total relamping cost" method. The other base is mercury lamp mortality. A greater number of lamps used for replacing burnouts would in turn have to be replaced if old lamps were used instead of new lamps. This increases the labor cost involved. All these things were considered in the calculations — not primarily because it was "good practice" to do so but because, in our opinion, it was the correct way to analyze "total relamping costs."

We agree with Mr. Phillips' suggestion that figures should have been included in Table III to permit correlation with Table IV. Actually, only the information for lines 4 through 14 would have been needed. For Case A, the figures are:

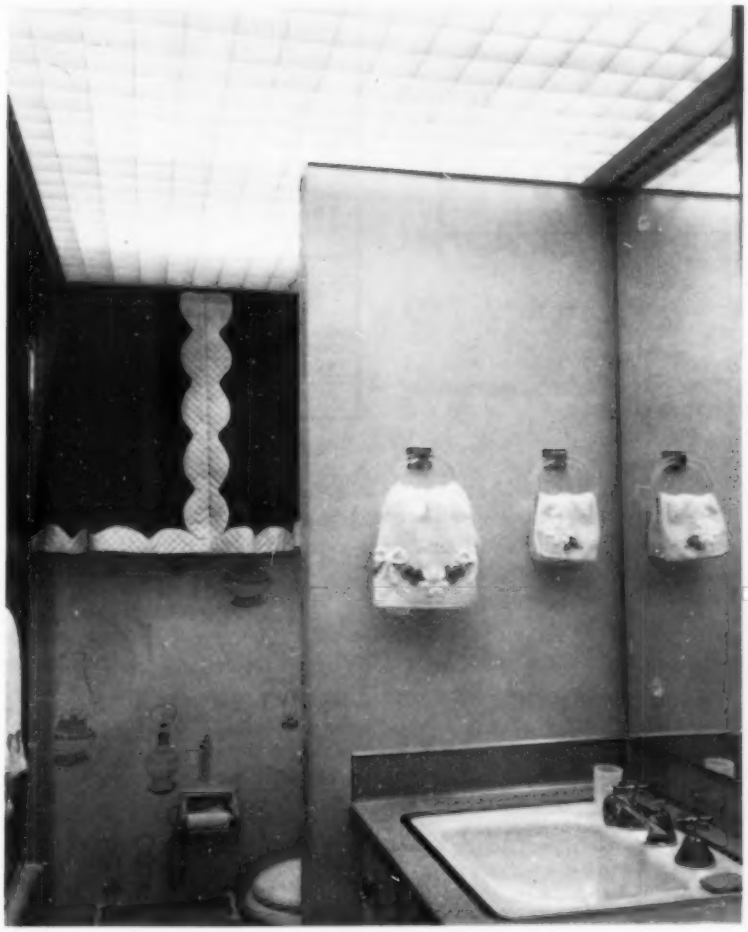
Line in Table III	Figure
4	$12
5	100
6	12000 hours
7	$3 per hour
8	40 minutes
9	8 minutes
10	$.01/kwh
11	440 watts
12	$30,000
13	120 months
14	4000 per *year*

The total investment cost per lamp actually used was $300. This figure consists of $200 for fixtures, ballasts, wiring and installation labor, which, amortized at 15 per cent over 10 years to include insurance and taxes comes to $300. This figure is higher than the average industrial installation and considerably lower than the average street lighting installation. However, if only half this figure had been used, the results of Case A would still have favored group relamping with new lamps. The optimum cycle would have been approximately 8000 hours instead of 7500 hours and would have resulted in savings of $4.50 per lamp per 12000 burning hours over random relamping, or $1.50 per lamp per 12000 hours over the best retirement program which occurred at about 10,000 hours under these conditions.

Regarding Mr. Phillips' objection to our statement that 250-, 700- and 1000-watt quartz-type lamps are near enough in design and performance to the 400-watt E-H1 to be considered essentially similar, we believe this statement to be true as a broad generalization and as a means of differentiating between these types and lamps with glass arc tubes (such as the A-H1 and A-H9). Mr. Phillips' comment that the lumen maintenance of 1000-watt types is poorer merely bears out the data presented in Fig. 1. Although a curve is not given for mortality of 1000-watt types, our test data indicate closer resemblance to the E-H1 curve of Fig. 2 than to the A-H1 curve of Fig. 3, and this resemblance also applies to the 250- and 700-watt types.

As to reduced lamp wattage for horizontal operation, this criticism does not seem to apply to E-H1 and related lamps of our manufacture, since tests show less than 1 per cent average drop in watts when they are operated on non-compensated ballasts. With specially compensated ballasts, the wattage is raised about 3 per cent to make up for the drop in luminous efficiency, characteristic of horizontal operation.

We will agree with Mr. Phillips that minimum "relamping cost" (as he defines it — we define it as "direct relamping cost") does not occur with minimum "cost of light." Our purpose was not to reach an arbitrary compromise between the two but to study the problem from a practical point of view that considered *both* maximum efficiency (light per dollar) and minimum out-of-pocket cost, and to develop a factual, meaningful method of analysis based thereon.



INSTALLATION IN COLUMBUS, OHIO.

Louverall Ceiling Bathroom

LIGHTING OBJECTIVE: To provide high level lighting combined with ultraviolet radiation in a bathroom.

GENERAL INFORMATION: The bathroom is 8 feet x 8 feet with an 8-foot ceiling. The ceiling is white (80 per cent reflectance); three walls are soft pink and the fourth is papered with a pattern all having the same 70 per cent reflectance; the floor is light gray (50 per cent reflectance). The lavatory and dressing table counters are of light gray laminated plastic (60 per cent reflectance) and the two basins match the pink walls.

INSTALLATION: Seven rows of wiring channels (The Wiremold Company catalog No. 2100), spaced 12-inches on centers, are mounted on the structural ceiling as shown in Fig. 2. Three rows of T-12 deluxe warm white slimline fluorescent lamps (two 48-inch and one 96-inch) operating at 425 ma alternate with four rows of 40-watt T-12 48-inch fluorescent sunlamps as shown in Fig. 3. The slimline fluorescent lamps and the fluorescent sunlamps are on separate circuits and all

(over)

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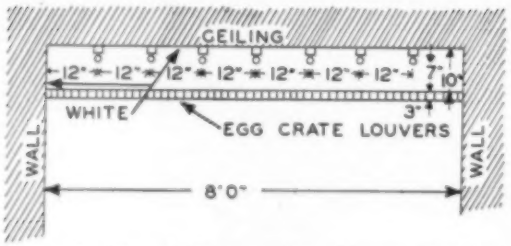

Figure 2. (above) Cross section of louverall ceiling cavity.

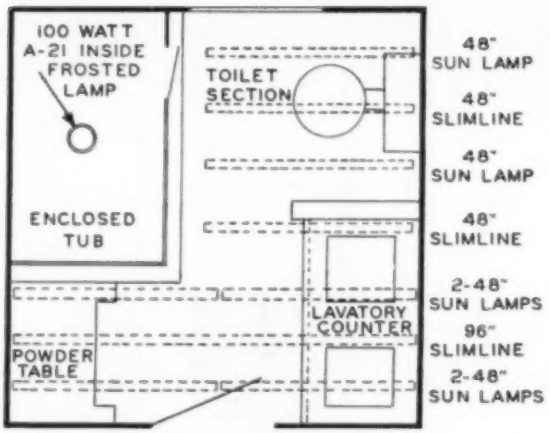

Figure 3. (right) Plan view of bathroom showing position of lamps.

lamps are positioned 7-inches above the egg-crate louvers. The louvered ceiling, of Neo-Ray baked white aluminum, has 3-inch cells which provide 45-degree shielding. It is in two sections, one four feet x four feet and one four feet x eight feet, and hung so that the bottom of the louvers is 13-inches below the structural ceiling. The inside of the cavity above the egg-crate louvers is painted white (see ceiling above).

The enclosed tub is illuminated by a recessed vapor-proof luminaire (The Art Metal Company catalog No. 3357) using a 100-watt A-21 inside frosted general service lamp (see Fig. 3).

Illumination measurements, with both circuits on, were as follows:

At lavatory counter	
center of counter (30" above floor)	46 ft-c
on forehead, standing at counter (64" above floor)	65 ft-c
At powder table	
center of table	35 ft-c
on forehead, seated at table	40 ft-c
on floor in this section	30 ft-c
In toilet section	
30" above floor	30 ft-c
on floor in this section	20 ft-c

It is reported that a person can expect suntanning results similar to mild exposure to midday sunshine and the possible health benefits from the ultraviolet radiation would result from exposures one quarter to one half of those required to produce tanning.

Lighting planned by Russell J. Lightcap, Interior Designer, Electrical Appliance Division, Westinghouse Electric Corporation, 246 East Fourth Street, Mansfield, Ohio.

Lighting data submitted by Blanche Waggener, Home Lighting Supervisor, Columbus and Southern Ohio Electric Company, 215 North Front Street, Columbus, Ohio, as an illustration of good lighting practice and to aid in the design of similar installations.

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TELECAST

LIGHTING NEWS OF CURRENT INTEREST

Across the Nation — I.E.S. Celebrates a Birthday

"From New England's rock-bound coast to California's sunny shores" — and, of course, across Canada's vast expanse — I.E.S. Sections and Chapters are holding celebration meetings of the Society's Fiftieth Anniversary. From January to September of this year, culminating in a special program at the National Technical Conference in Boston, I.E.S. nation-wide is celebrating 50 Golden Years of progress.

Mainspring of these local programs is the overall program worked up by the Golden Anniversary Committee, R. G. Slauer, Chairman. This committee has with masterly planning furnished Sections and Chapters with a complete program of celebration — the suggested text for speeches, complete sets of appropriate slides, and an Anniversary pin. Their program suggestions also included a birthday cake, a feature enjoyed with enthusiasm at nearly all the Anniversary meetings.

The gold *(real gold)* Anniversary pin, to be won by a member in each Section and Chapter, has been supplied by the committee to designate that member as his local group's official ambassador to the Boston Conference. The awarding of the pin, so far, has been done by various means: baked in cake with the lucky winner finding it in his slice, or won in a drawing of dinner checks, or awarded as an honor to a most distinguished member.

Another feature of the general program is that a member of the National Council be present at each birthday celebration, to speak on the aims, objectives, organization and work of the Society.

Supplementing the Anniversary Committee's general program, local enthusiasm has taken over, as is evidenced by the reports and photographs of the Anniversary meetings which follow:

Southern California Section

January 4, Roger Young Auditorium, Los Angeles.

Southern California led off the celebrations with their party on January 4, when Section Chairman Roy Kreyser and National Director John S. Walsh joined hands in cutting the large birthday cake. One highlight of the evening was the introduction of seventeen Past-Chairmen of the Section and two Members Emeritus, who were seated at a special table immediately in front of the head table.

Chairman Kreyser presented a short history of the Southern California Section, and Dave Pence, Charter Chairman, also spoke briefly. Mr. Walsh gave a talk on the history of the National I.E.S. organization.

The Anniversary pin was won, by dinner check drawing, by James E. Ken-

SOUTHERN CALIFORNIA SECTION. Lucky Anniversary pin winner James E. Kennedy, left, with Section Chairman Roy H. Kreyser.

SOUTHERN CALIFORNIA SECTION. Clockwise from left: Members Emeritus, W. P. "Teddy" Bear, and Past-President L. H. Graves. Past-Chairmen: Donald W. Prideaux; Roy E. Dahlin; Oscar W. Meissner; Leonard W. Towner; Don K. Grandey; L. W. "Barney" Luley; Ted H. Shepherd; Urban L. Beh; H. B. May, Jr.; Lloyd A. Gates; R. A. Crosby; E. A. Hutchinson; H. T. Crane; Arthur W. Nye; Walter A. Alden; Dave C. Pence; F. Edwin Blair.

I.E.S. Golden Anniversary Committee

R. G. Slauer, *Chairman*

Berlon Cooper	S. G. Hibben
Julius Daniels	Kirk M. Reid

nedy, who will become the official representative for the Section to the Boston Conference.

The technical portion of the meeting featured H. S. Davis, American Electronics Inc., and Bill F. Jones, Smoot-Holman Co., as speakers.

Chicago Section

January 6, Grand Ballroom, Midland Hotel, Chicago, Ill.

Leo Dolkart, a Charter Member of I.E.S., was honored at the Society's Fiftieth Anniversary meeting of one of its Charter groups, the Chicago Section. Mr. Dolkart was presented with the Anniversary Pin, making him the Section's representative at the Boston Conference this September.

CHICAGO SECTION. Chairman R. J. Diefenthaler presenting Anniversary pin to Charter Member Leo Dolkart. G. K. Hardacre applauds.

CHICAGO SECTION. Some Chicago Section Past-Chairmen, left to right: Paul F. Kauffman, John A. Harrington, Edwin D. Tilson, Arthur F. Larson, Carl W. Zerson and Glenn Boyd. Also featured in photo "the cake."

Attendance was over 250 to hear G. K. Hardacre speak on "What I.E.S. Has Done and What It Means Today."

Following the Birthday celebration, John J. Neidhart, Westinghouse Electric Corp., and Chairman of the I.E.S. Committee on Office Lighting, spoke on the new Recommended Practice for Office Lighting.

Central New York Section

January 6, Liederkranz Club, Syracuse, N. Y.

The I.E.S. Emblem in blue and gold topped the birthday cake at the Central New York Section's anniversary meeting. The room also was specially decorated for the occasion, with a banner designed by High Miller, display manager with Niagara Mohawk, which carried the phrase, "50 Years" and the I.E.S. insignia.

Albert H. Clarke, Crouse-Hinds, was the principal speaker, reporting on the 1955 Zurich meeting of the International Commission on Illumination, and showing slides of lighting installations in Europe.

CENTRAL NEW YORK SECTION. Left to right, standing: John S. Haney, Ted Harmon, L. W. Kiesewetter, A. H. Clarke, Don Vincent, A. E. Krawcek, Herb Baxter; seated: Floyd Green, Paul Robson, Ray Kiesewetter, D. C. Geyer, E. D. Britt, Dr. H. P. Gage, Jim Bigley, Earle Edwards.

Georgia Section

January 9, Antler Room, Elks Club, Atlanta, Ga.

Planned from as early as the beginning of last October, the Georgia Section's successful Anniversary meeting centered on a reunion with Past-Chairmen of the Section and the Residence Lighting Forum. A record must have been set by the accomplishment of having every Past-Chairman present at the opening of the festivities.

J. Dixon Mitchell, Southern Regional V-P and member of the Section, presented a history of the Society. Cyrus M. Wallace reminisced about the forerunner of the Georgia Chapter, which was known as the Atlanta Lighting Club. This Club met for luncheon weekly during 1938-1939, and due to a dearth of visiting lighting experts, many of the meetings had speakers on subjects quite foreign to the lighting field. (Amusing examples of this were the luncheon which featured an Eastern Airlines pilot and stewardess, and the one where the lighting club heard of the dubious practicability of running City trucks on sewage disposal gas.) The archives produced the information that the luncheon tab was 35 cents each, and that some individuals questioned this exorbitant price.

GEORGIA SECTION. Judd Lough, left, and T. Taylor Peake come back for more.

GEORGIA SECTION. Past-Chairmen: left to right, seated: Mary Bush, Fern Moran, Emily Alexander, Elizabeth Parker, Faye Bonner, Ruth Morris and H. M. Horton; standing: Judd Lough, T. Taylor Peake, Col. C. H. Burch, I. H. Stockel, Cecil L. Cannon, James F. Whitehead, Walter F. Nelson, Jack H. Murrah, Henry F. Barksdale, Johnnie Sweatte, J. B. Browder, Hamilton H. Corey and J. Dixon Mitchell.

Jack H. Murrah, of Georgia Power, gave a running commentary on the history and accomplishments of the Georgia Section and its Sister, the Residence Lighting Forum.

Highlight of the proceedings was the presentation of the Golden Anniversary Pin to T. Taylor Peake, a Charter Member of the Lighting Club. Mr. Peake was also presented with a Certificate of Appreciation for his many contributions to the Section, and as a final honor was asked to cut the birthday cake.

Attendance at the Georgia Section's party was 114.

Southwestern Section

January 9, Stoneleigh Hotel, Dallas, Texas.

The Southwestern Section is, so to speak, parent of the six other Sections and Chapters comprising the Southwestern Region, and its celebration of the I.E.S. Golden Anniversary featured six of the eight Regional Vice-Presidents who have served the area. Other guests included 14 of the 19 living Chairmen of the Chapter and Section, and 10 of the 13 living Secretary-Treasurers.

SOUTHWESTERN SECTION. Blowing out the candles on the cake are Mrs. Perry Nelson, Mrs. Charlie Shearer and Mrs. Joe Burns. Cheering their efforts, from the rear, are John G. Felton, Jr., Southwestern Regional V-P, P. M. Rutherford, Jr., Mrs. P. M. Rutherford, John E. Metzenthin, Section Chairman, and Mrs. John E. Metzenthin.

SOUTHWESTERN SECTION. Charter Members of the Section, W. E. Holland and Miss Ethelle Hudson.

Especially honored were two of the original ten members of the Southwestern Section as a Chapter. These are W. E. Holland, now Vice-President of Dallas Power and Light, and Miss Ethelle Hudson, Lighting Consultant with the utility. Miss Hudson, happily, was the winner of the Anniversary pin.

P. M. Rutherford, Jr., was Toastmaster and also spoke on "The Southwestern Section in Review." John G. Felton, Jr.,

SOUTHWESTERN SECTION. Past Regional Vice-Presidents, left to right: H. R. Heitzman, P. M. Rutherford, Jr., Floyd A. Covington, Sr., W. E. Folsom, M. J. Myers, and currently serving, John G. Felton, Jr.

PHILADELPHIA SECTION. Attendance was 275.

PHILADELPHIA SECTION. Left to right, Homer Manwaring, R. F. Hartenstein, Ted Lauer receiving Anniversary pin cut from cake by G. William Wagner, George E. Whitwell and S. G. Hibben.

Vice-President of the Southwestern Region, presented "Fifty Years of Progress in the I.E.S."

The three-tier Birthday Cake had 50 candles on the bottom layer, 30 on the middle layer, and was topped with the I.E.S. Emblem in color.

British Columbia Section

January 10, White Spot Banquet Room, Vancouver, B. C.

I.E.S. history and that of illumination were summarized by six distinguished speakers at the I.E.S. Birthday party celebrated in Vancouver, B. C. Following a special full course anniversary dinner and the cutting of the birthday cake, the speakers were introduced by British Columbia Section Chairman J. H. Gilbreath.

First was Blair E. Plowman, Vice-President of the Pacific Northwest Region, who discussed the history of the Society and of the Region, emphasizing the accomplishments of I.E.S. and its contribution to human welfare particularly through its research and technical committees. He noted especially that the modern consideration of total seeing environment which includes high levels of comfortable lighting has resulted from the Society's recommendations.

R. G. Scott, a Past-Chairman of the Section and one of the original members of the Vancouver group, presented an interesting review of the history of the British Columbia group from 1934 to 1956.

W. J. Lind, Past-Regional V-P, spoke on "Progress in Light Sources," giving the story of the developments in sources since Edison's lamp of 1879.

"Evolution of Lighting Fixtures" was the subject chosen by E. E. Ackland, a Past-Regional V-P and Past-Chairman of the Section.

Kenneth Reid, another Past-Chairman of the Section, spoke on "Street Lighting Progress," reviewing this phase of lighting in British Columbia over a period of 90 years — from gas street lighting to the present.

Lighting progress to date was summarized by A. E. Simpson, who also extended into the future, anticipating what is to come. Mr. Simpson is also a Past-Chairman of the Section.

Philadelphia Section

January 10, Benjamin Franklin Institute, Philadelphia, Pa.

Philadelphia Section's Anniversary meeting, one of the largest of the I.E.S. celebrations, was distinguished also by the attendance of a long list of notables. President R. F. Hartenstein was there, as were five Past-Presidents: Dr. George S. Crampton, Dr. S. G. Hibben, Duncan

(Continued on page 13A)

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(*Continued from page* 10A)

Jones, Lee Tayler and A. H. Manwaring. Also C. C. Shotwell, Director, 14 Past-Chairmen of the Section, and George E. Whitwell, Vice-President of Philadelphia Electric Co., who gave an inspiring address on "The Golden Future of I.E.S."

Mr. Hartenstein, Mr. Whitwell and Section Chairman G. Williams Wagner collaborated on cutting the Anniversary cake. Lucky winner of the pin was Ted Lauer, who will be Boston-bound.

Attendance was limited, by catering facilities, to 275.

New England Section

January 10, Lenox Hotel, Boston, Mass.

Members of the American Institute of Architects, American Institute of Electrical Engineers and the Lighting Engineers Club were invited to join with the I.E.S. members of the New England Section at their celebration of their Golden Anniversary, and to share its birthday cake.

Julius Daniels, Section Historian and a Past-President of I.E.S., spoke on early Society activities and its early members. Mr. Daniels was followed by C. W. McCormick, Northeastern Regional V-P, who discussed the growth of the Society and its services over the years.

Russell N. Kierstead was the winner of the Anniversary pin identifying him as the Section's representative to the Boston Conference (involving only the short trip from Lowell, where he is with the Lowell Electric Light Co.).

The featured address of the evening was given by Isidor Richmond, of Isidor Richmond and Carney Goldberg, Architects, whose subject was "Architecture and Man-Made Lighting." Mr. Richmond urged a better and closer cooperation between the illuminating engineering and architectural professions.

NEW ENGLAND SECTION. Speakers, left to right, Julius Daniels, Section Historian; C. W. McCormick, Northeastern Regional V-P; W. M. Elmer, Section Chairman, and guest speaker Richard Isidor Richmond.

TENNESSEE VALLEY SECTION. The Chattanooga third of the celebration. Left to right, W. B. Taylor, Charter Chairman of the Section; Charles H. Patterson, current Chairman; Dr. E. F. Lowry, guest speaker, and Buford H. Martin, Chairman of the Tennessee Valley Residence Lighting Forum.

Tennessee Valley Section

January 16, Peggy Wales Tea Room, Nashville, Tenn.

January 17, Hamilton Room, Hotel Patten, Chattanooga, Tenn.

January 18, Oak Room, Farragut Hotel, Knoxville, Tenn.

Not one, not two, but three celebrations were held by the Tennessee Valley Section, each observed jointly with the Tennessee Valley Residence Lighting Forum. Three parties and three cakes. But only one Anniversary pin, which was won, by chance drawing at the Nashville meeting, by Burt Adair, Line Material Co.

Section Chairman Charles Patterson, Local Activities Chairman Leslie Pierson, Buford Martin and Bullock Taylor took turns at presiding over the meetings, and speaking on the history of the I.E.S., and the Residence Lighting Forum. Dr. Erwin F. Lowry of Sylvania Electric Products Inc. was guest speaker at all three parties, with the subject, "Electroluminescence."

Total attendance was 117.

Western New York Section

January 17, Hunt Room, Park Lane Restaurant, Buffalo, N. Y.

A 50-year recap of I.E.S. history and the advances in the lighting industry, presented by L. C. Twichell, Director of the Society, was part of the Western New York Section's observance of the Anniversary.

(*Continued on page* 14A)

WESTERN NEW YORK SECTION. Anniversary pin is adjusted on Hugo Jaeger by Section Chairman W. E. Hayes.

PITTSBURGH SECTION. Honor guests Mr. and Mrs. Henry N. Muller. Mr. Muller was a founder of the Section.

(Continued from page 13A)

Another part was the awarding of the special gold Anniversary pin to Charter Member of the Section Hugo Jaeger, making him the Section's representative to the Boston Conference.

Speaker of the evening was Anson H. Russell, of General Electric Co., who spoke on "High Frequency Fluorescent Lighting." Section Chairman Willard E. Hayes presided.

Pittsburgh Section

January 17, Terrace Room, Hotel William Penn, Pittsburgh, Pa.

A gala Birthday banquet commemorated Pittsburgh's part in the fifty years of I.E.S., evoking nostalgic memories of the city in 1906, honoring the founders of the Section, and in an impressive candle-light service reaffirming their pledge to the principles and purposes of the Society.

Honored guests included two of the founders of the Section: Henry M. Muller and Lewis J. Kiefer; 18 Past-Chairmen of the Section; President R. F. Hartenstein; Director J. S. Schuchert and East Central Regional V.P. Nelson Warner. Mr. Hartenstein spoke on the Boston Conference next September, Mr. Schuchert was Toastmaster, and Mr. Warner spoke on the principles and purposes of the Society and outlined its development, growth and accomplishment. G. H. Maize, a Past-Chairman of the Section, brought back nostalgic memories of people, scenes and events of Pittsburgh 1906, by his presentation using a large screen, slides and commentary. He introduced the honor guests with pictures of them in early days.

Also honored were founders and active leaders of allied organizations in the electrical field, founded in the area at about the same time as the Pittsburgh Section, I.E.S.

The Anniversary pin was presented to Al Paulus, Westinghouse Electric Corp., for his long service to I.E.S., on both local and national level.

The climax of the banquet came with the commemoration ceremony conducted by Hugh S. James, Chairman of the Section. This was a candle-light service in which the spirit of illumination was taken from a bust of Thomas Edison and a replica of his first lamp to Mr. James' symbolic golden anniversary candle, thence to each of the gold candles to the honor guests, and thence to the members and guests of the Pittsburgh Section.

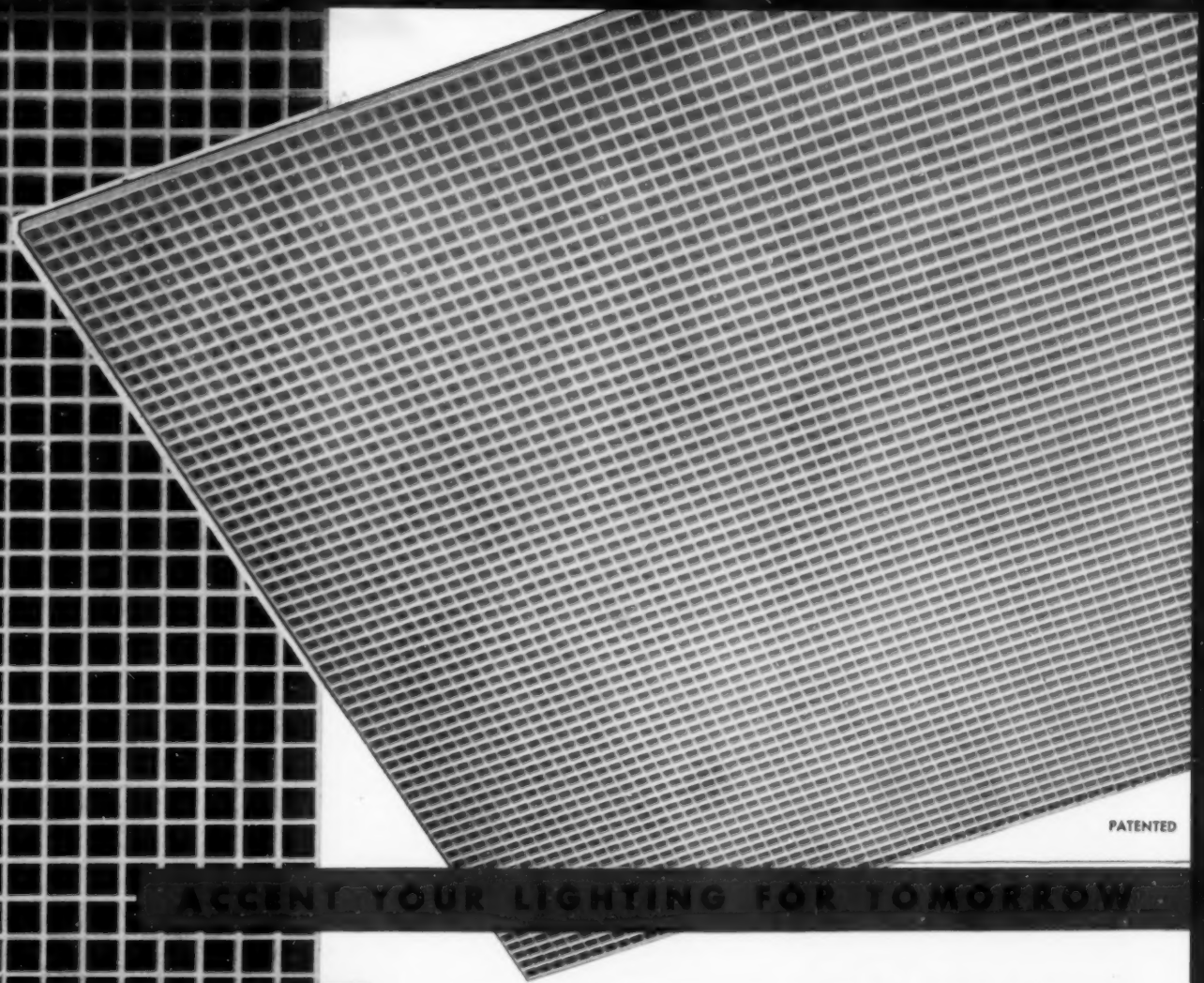
New York Section

January 17, Hotel McAlpin, New York, N. Y.

New York's Anniversary pin was presented to one of the Section's most distinguished members at its Birthday luncheon meeting — William F. Little, of E.T.L., Past-President, Fellow and Gold

(Continued on page 16A)

PITTSBURGH SECTION. Lighted candles held aloft in impressive candle-light service.



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Fine quality of light — soft and glare-free, efficient and inexpensive — coming from a new source that is beautiful in itself, but simple and unobtrusive — accenting the features of a room rather than competing with them.

- **Clean, pleasing appearance**
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- **Proper cut-off for high quality illumination**

See this *new* plastic lighting medium, whose amazing versatility of design gives full scope to the architect's creative ability. Write today for your free copy of the booklet "Plastics in Modern Lighting."

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Consultants and designers for the lighting industry since 1939

NEW YORK SECTION. In photo at left, William F. Little cuts cake and S. G. Hibben looks on. At table are C. W. McCormick and Section Chairman Lou Goren. In photo at right, S. G. Hibben addresses the group.

(Continued from page 14A)

Medallist. Also honored were Past-Chairmen of the Section who were seated at the head table. All 150 members and guests attending, however, shared in the huge cake. Section Chairman Lou Goren presided.

Milwaukee Section

January 17, Astor Hotel, Milwaukee, Wis.

A huge golden cake with a huge golden candle, and a program to interest everyone insured the success of the Milwaukee Anniversary celebration. The dinner was attended by 116 members and guests and the meeting by 163. The anniversary part of the program featured Director Brooks Chassaing on I.E.S. History, Midwestern Regional V-P J. R. Chambers on Regional Functions and Irv Illing on Local Activities.

M. H. Bruesewitz was the winner of the Anniversary pin.

H. Creston Doner, of Libbey-Owens-Ford Glass Co., was the featured speaker, discussing residential design, color and lighting. Ted Cox, Managing Director of the American Home Lighting Institute, also spoke.

MILWAUKEE SECTION. Left to right, Edwin Schnoll, Mrs. Schnoll, H. Creston Doner, Rex Fransway, Beverly Bunn, Brooks Chassaing, I. L. Illing, Ralph Chency, Tex Cox and William Kuhnke.

Southern Colorado Chapter

January 24, Southern Colorado Power Company Auditorium, Pueblo, Colo.

Brooks Chassaing, Director of the Society, was the guest speaker at the Anniversary meeting of the Southern Colorado Chapter, and assisted Chapter Chairman William D. Proudfoot with the cutting of the birthday cake.

SOUTHERN COLORADO CHAPTER. Cake is cut by Section Chairman William D. Proudfoot, assisted by Director Brooks Chassaing.

Kenneth J. Stines, Pueblo architect, found the Anniversary pin in his slice of cake, designating him as the Section's official representative to the Conference.

(Continued on page 19A)

P&K ALL-ALUMINUM STANDARDS AND ARMS:

ROOSEVELT BOULEVARD, PHILADELPHIA, WHERE 1,000 NEW LIGHTS ON P & K ALL-ALUMINUM STANDARDS AND ARMS WILL MARK THE LAUNCHING OF PERHAPS THE MOST FAR-SIGHTED STREET LIGHTING PROGRAM OF ALL TIME.

AT THE END OF A 10 YEAR PROGRAM 70,000 STREET LIGHTS WILL HAVE BEEN INSTALLED AND MODERNIZED. ALL POLES, BRACKETS AND LUMINAIRES BEING USED ARE ALUMINUM.

MR. HAROLD E. MASON
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THE LOGICAL CHOICE IN PHILADELPHIA

Like their 500 P & K predecessors installed in the "World's Workshop" years ago, these new P & K 32-ft. All-Aluminum Standards, and P & K 12-ft. Tapered Elliptical Arms will prove *the wisest investment in modern lighting.*

LIGHT-WEIGHT, HIGH STRENGTH, AND CORROSION-FREE FOR EASY INSTALLATION AND LONGEST LIFE.

NO NEED FOR PROTECTIVE MAINTENANCE, NEVER NEED PAINTING.

NO SEAMS, NO FRILLS, NO SCROLLS, NO TIE-RODS. ITS MODERN SIMPLICITY IS CONTEMPORARY TODAY OR TWENTY YEARS FROM TODAY.

PROVES MUCH LOWER IN COST OVER THE YEARS.

Write for latest P & K catalog . . . and use the P & K advisory and planning services without obligation.

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Lighting Scheme designed and specified by
Leonard Gussow, Consulting Engineer of Detroit, Mich.

•

W. D. Gale Company, Electrical Contractors

Showing 25 years of progress from an inefficient incandescent cove lighting installation to a combination of Rambusch Medium Downlites and Day-Brite #89140 series cove strips. There are 100 Rambusch lighting representatives in the country—one of them is near you and anxious to serve you.

RAMBUSCH **DESIGNERS • MANUFACTURERS**
40 WEST 13th STREET, NEW YORK 11, N. Y.

(Continued from page 16A)

Golden Gate Section

January 19, Three Little Swiss Restaurant, San Francisco, Calif.

Four pioneers of I.E.S. — two in absentia — were honored by the Golden Gate Section at the Anniversary meeting. James Cravath, Charter Member of the Society, and first Chairman of the Chicago Section, was presented with the Anniversary pin by Harold A. Wright, Section Chairman. Mr. Cravath also cut the large birthday cake.

Honored with Mr. Cravath were Robert S. Prussia, who was present, and W. W. Hanscomb and Romaine W. Myers, unable to attend, all of whom helped develop California's first state safety standards for lighting in 1920 and were charter members in that year of the Northern California Chapter. The meeting was saddened by announcement of the death of Mrs. Myers that afternoon. The tribute to the four pioneers was paid by William A. Cyr, associate editor of *Electrical West*.

Also on the program was "Floodlighting — Recent Developments," by Towner Buckley, Crouse-Hinds Co.

GOLDEN GATE SECTION. James Cravath, Charter Member of I.E.S. cuts the cake. On his left is Section Chairman Harold Wright, and seated at table are two Past Regional Vice-Presidents, Fred Wellhouse and Carl Martin. Photo courtesy of *Electrical West*.

St. Louis Section

January 19, Gatesworth Hotel, St. Louis, Mo.

To the last detail of gold-lettered place cards, the St. Louis Section celebrated the Anniversary in their usual complete style. The head table was elaborately decorated with candelabras and featured an immense three-tiered cake. Immediately in front of the head table was another large U-shaped table where twelve past chairmen and their wives were seated.

During an intermission, Mrs. Carter Lewis, wife of the Section's Charter Chairman, cut the cake. At that time, a drawing was held to award the Anniversary pin. Ironically, the winner was Brooks Chassaing, a Director of the Society and immediate Past-Chairman of the Section. Mr. Chassaing later addressed the group.

Guest speaker was Miss Myrtle Fahsbender, Director of Residential Lighting, Westinghouse Electric Corp., and a Fellow of I.E.S., who spoke on "Light to Live By."

Among the 137 members and guests attending, there were three I.E.S. Fellows, a Director, a Past Director and Past Regional Vice-President, and twelve Past-Chairmen of the Section.

ST. LOUIS SECTION. Head table, Past-Chairmen's table and part of the attendance of 137 members and guests.

12-Week Advanced Course Given by New York Section, I.E.S.

Intended as an extension of the Fundamentals of Illumination Course, which is presented annually by the New York Section of I.E.S., an Advanced Course in Lighting Design and Layouts is being given. It has been constructed with a view to making it useful to those who have considerable experience in the lighting field, but who may wish to learn more about other branches of the field and the latest techniques in their own field of interest. A knowledge of the fundamentals of lighting through experience or other instructions will be assumed.

Instructors for the course, all members of the New York Section, are:

H. Peters, Consolidated Edison Co.
L. Goren, Smith raft Lighting Division, A. L. Smith Iron Co.
P. He rick, General Electric Co.
J. Hamilton, Day-Brite Lighting, Inc.

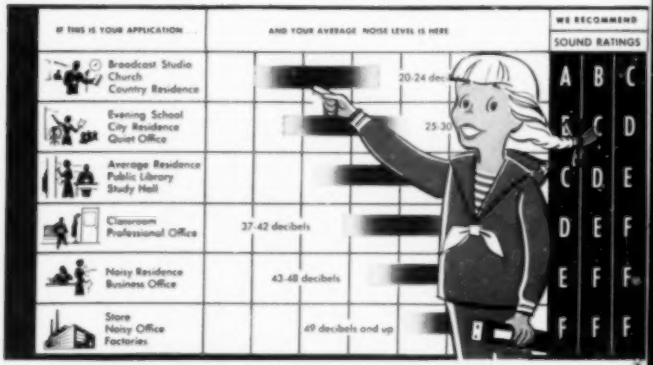
The twelve sessions are as follows:

February 20 — Interior Lighting Design — H. Peters
February 27 — Office Lighting — H. Peters
March 5 — Office Lighting — H. Peters
March 12 — Schoolroom Lighting — L. Goren

(Continued on page 23A)

Flora shows you*

General Electric



1. SOUND RATING—Only G-E ballasts are sound-rated to assure you of meeting your sound level requirements. You can choose the proper G-E ballast whether it's for a quiet installation or for an application where noise is less important. G-E sound rating eliminates expensive noise complaints.

4. LAMP-MATCHED DESIGN—The ballast governs light output and life of the fluorescent lamp. G-E ballasts are lamp-matched to provide up to 50% longer lamp life and up to 30% more light output. Here you save two ways—lower lamp replacement costs and more light from your installation.

Whether you use, install, specify or make fluorescent fixtures, G-E ballasts mean savings to you!

The six reasons why you save, described by Flora above, grow out of these simple facts:

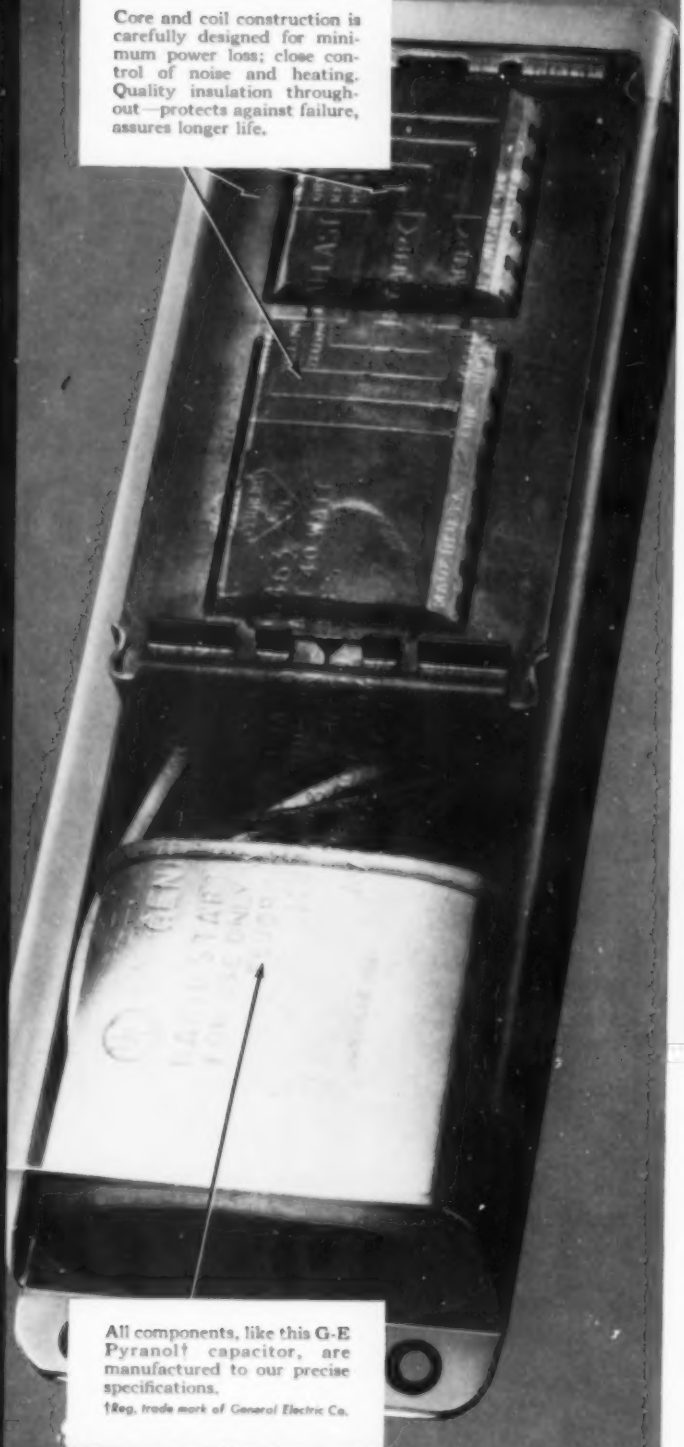
- **G-E ballasts are designed to high engineering standards (1, 3, 4, 5 above).**
- **G-E ballasts are made under exacting quality control standards (2 above).**
- **G-E ballasts are backed by complete sales and engineering services (6 above).**

Only G.E. offers you all these money saving features.

In every conceivable way, we make sure you get more when you use G-E ballasts. For example, G-E engineering standards

Copyright 1954, General Electric Company.

Core and coil construction is carefully designed for minimum power loss; close control of noise and heating. Quality insulation throughout—protects against failure, assures longer life.



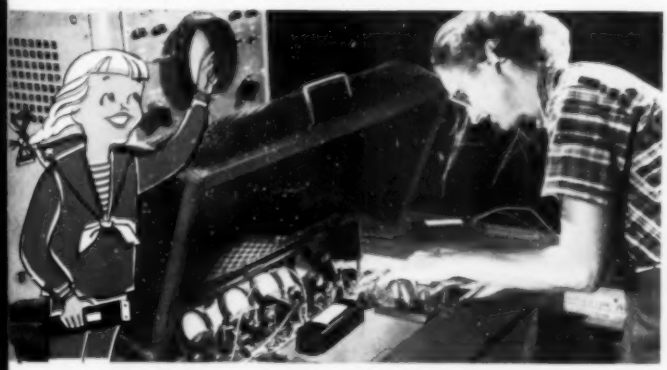
All components, like this G-E Pyranol† capacitor, are manufactured to our precise specifications.

†Reg. trade mark of General Electric Co.

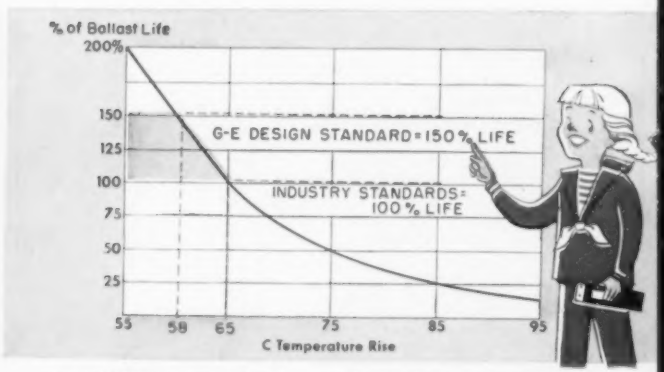
Every part of a G-E ballast is carefully designed, manufactured, tested and assembled to give you the best ballast value.

six ways . . .

ballasts help you save lighting dollars



2. UNIFORMLY HIGH QUALITY—Lighting specifiers have learned to depend upon the consistently high quality of G-E ballasts. Rigid material specifications and constant production line tests mean uniformly good ballasts; save lighting dollars on early replacement and maintenance costs.



3. LONGER LIFE—G-E ballasts are designed to operate 10% cooler than U.L. and Certified Ballast Manufacturers' standards. Tests show that a 10% reduction in ballast temperature rise can mean up to 50% longer ballast life, giving you half again as much ballast life!

5. PROVED PRODUCT LEADERSHIP—General Electric has the largest group of specially trained ballast design and development engineers in the industry. They're constantly improving G-E ballasts, assuring you of all benefits of top quality when you "specify" General Electric.

6. COMPLETE CUSTOMER SERVICES—General Electric's extensive sales, warehousing, and engineering organization is anxious to serve you. These unequalled facilities can provide services for you which no other ballast manufacturer offers. These extra services mean real saving to you.

actually exceed the specifications established by the Certified Ballast Manufacturers where extra quality pays off to you. Another example: Ten quality control stations make dozens of physical and electrical checks during manufacture to assure that each ballast measures up to the high G-E standards.

Next time, specify General Electric Ballasts. Dollar for dollar they're your best ballast value.

LOOK FOR THIS G-E BALLAST TAG →

A G-E ballast tag on your fixture is proof that it's equipped with a top-quality ballast. It's the easy way to be certain. For further information on G-E ballasts, contact your nearest G-E Apparatus Sales Office or G-E Distributor. General Electric Company, Schenectady 5, New York. 431-7

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When you want a lens to make light behave the way you want it to, we'd like to help you.

You can use our staff and research facilities to solve optical problems or to confirm your own findings.

You can use our production facilities to get the shape, size and configuration lens you need.

We've been helping people obtain specialized lightingware and mass producing lenses to close tolerances, economically for over 80 years.

CORNING GLASS WORKS 8-88 **Crystal Street, Corning, New York**

Corning means research in Glass

(*Continued from page* 19A)

March 19 — Industrial Lighting — L. Goren
March 26 — Industrial Lighting — L. Goren
April 2 — Public Building Lighting — P. Herrick
April 9 — Public Building Lighting — P. Herrick
April 16 — Store Lighting — J. Hamilton
April 25 — Store Lighting — J. Hamilton
April 30 — Outdoor Lighting — P. Herrick
May 7 — Outdoor Lighting — P. Herrick

Classes are being held at the Consolidated Edison Building, 4 Irving Place, New York City. Tuition is $10 to members of I.E.S., A.I.E.E., A.I.A., E.A.C. and employees of Sustaining Members of I.E.S.; $20 to all others.

Basic Lighting Design Course Offered by Cleveland Section

The Cleveland Section of I.E.S. offered a Basic Lighting Design Course, intended primarily for newcomers to the lighting industry. The times: 8:00 to 10:00 p.m., February 7, 14, 21, 28; March 6 and 20. The place: Auditorium of the Electrical Building, Case Institute of Technology. The course:

Light Begins with the Light Source
Introduction to Lighting
Lighting Design Procedure
School and Office Lighting
Outdoor Lighting
Store Lighting
Industrial Lighting

Instructors were recruited from the membership of the Cleveland Section. Registration was $5.00.

Photo courtesy Canadian Broadcasting Corp.

MONTREAL Section members at TV studio, January 13.

Montreal Section Studies Television Lighting

Eighty members of the Montreal Section, I.E.S., visited the television studios of the Canadian Broadcasting Corp., January 13, to see a demonstration of television lighting techniques. The cameras fed directly into a receiver at the side of the studio, allowing the audience to assess the various types of lighting, which were described by Charles Frenette, Technical Director of the Montreal Studios. Section member, Bob Conroy, of Canadian General Electric, served as model for the demonstration.

The Montreal unit of the Canadian Broadcasting Corp. is the largest television center in Canada. The majority of its programs are for the French network.

1956 Regional Conferences

Region	Place	Date
Southern	Birmingham, Alabama Thomas Jefferson Hotel	April 5-7
Southwestern	Fort Worth, Texas Hilton Hotel	April 8-10
South Pacific Coast	San Francisco, California Mark Hopkins Hotel	April 11-13
Pacific Northwest	Spokane, Washington Davenport Hotel	April 19-21
Inter-Mountain	Salt Lake City, Utah Utah Hotel	April 26-28
Great Lakes	Toledo, Ohio Commodore Perry Hotel	May 7-8
Midwestern	Indianapolis, Indiana Severin Hotel	May 10-11
Canadian	Quebec, Quebec Chateau Frontenac	May 17-18
East Central	Washington, D. C. Shoreham Hotel	May 24-25

Organization Proposed of Canadian Lighting Bureau

Decision to form a Canadian Lighting Bureau was made at a special meeting of some 45 Canadian lamp and fixture manufacturers, held in Toronto on January 16. Main object of the proposed Bureau would be to promote better lighting, with the aim of increasing the Canadian market for lighting equipment.

Chairman of the meeting was B. A. Wilson, vice-president of J. A. Wilson Lighting and Display Ltd., Toronto, who explained that the Bureau would attempt to correlate in Canada the activities carried on in the United States by the National Lighting Bureau, the American Home Lighting Institute and the Edison Electric Institute.

An Organizational Committee was appointed to establish the Bureau and to recruit members from companies in the lighting field. Members of this commit-

(*Continued on page* 24A)

(Continued from page 23A)

tee, which later chose Mr. Wilson as chairman, are:

E. Barker, Electrolier Manufacturing Ltd.
J. W. Bateman, Canadian General Electric Co. Ltd.
W. Brooks, Brooks Lamp and Shade Co. Ltd.
H. L. Wright, Curtis Lighting of Canada, Ltd.
W. A. Dalrymple, Amalgamated Electric Corp., Ltd.
P. G. Kirkpatrick, John C. Virden Ltd.
Paul Ducasse, Rosemont Industries Ltd.
W. Sutterlin, Columbia Electric Ltd.
L. A. Van Duzer, Peerless Electric Co. Ltd.

E.E.I. Announces March Sales Conference

The 22nd Annual Sales Conference of the Edison Electric Institute will be held at the Edgewater Beach Hotel, Chicago, Ill., March 26 through 29, 1956, as announced by O. R. Doerr, Chairman of the E.E.I. Commercial Division Executive Committee.

The conference will open March 26 with meetings of the 22 EEI Commercial Division Committees. March 27 sessions will consist of a joint meeting between the Commercial and Industrial groups and sessions of the Residential and Farm Groups. General Sessions will begin March 28 and continue through March 29.

Fundamentals of Lighting Course At University of Colorado

Fundamentals and Techniques of Lighting Practice is the title of a 16-week course being presented at the Extension Center of the University of Colorado in Denver. Instructor is G. B. Buck, District Engineer of the General Electric Co. Lamp Division, and Past Regional Vice-President of the Inter-Mountain Region of I.E.S. Mr. Buck is a member of the Rocky Mountain Section.

The two-hour classes are being held February 13 through June 4, at the East High School. Tuition is $18. Topics to be covered include:

February 13 — Elementary Physics of Radiation — The three dimensions of light.
February 20 — Incandescent Lamps and Circuits.
February 27 — Mercury Lamps and Circuits.
March 5 — Fluorescent Lamps and Circuits.
March 12 — Other Light Sources and Applications.
March 19 — General Lighting Design.
April 2 — Light and Life.
April 9 — Industrial Lighting Practice.
April 16 — Office and School Lighting Practice.
April 23 — Commercial, Display and Theatrical Lighting.
April 30 — Fixture Design and Photometry.
May 7 — Lighting Economics and Cost Analyses.
May 14 — Wiring and Circuits.
May 21 — Other Lighting Fields.
May 28 — New Techniques in Lighting.
June 4 — Refresher Symposium — Review of course and questions; analysis of special problems presented by the class.

Operation I.E.S.

Who controls the management of I.E.S.? What is the basic function of the Society? These are questions individual members often ask visiting staff and officers. Good questions, too, and items well worth discussion because both the function and management of I.E.S. are really controlled by the membership itself.

The basic function of the Society is well defined in the statement of its aims, adopted at its founding in 1906. To wit: ". . . organized for the advancement of the theory and practice of illuminating engineering and the dissemination of knowledge relating thereto." Fulfillment of this aim is carried out by the membership itself. Individual members man the committees which study the theory and encourage the practice of good lighting techniques; they plan the programs, the study clubs, illumination courses, and many other projects which further the dissemination of lighting knowledge. Every member active in any aspect of illumination, and especially those members who are participating actively in I.E.S. work, is carrying out the function of the Illuminating Engineering Society.

This membership-committee relationship works in a very effective manner. The committee structure is familiar to most members, but might bear repeating here. All committees and their personnel are appointed by the President, subject to approval of the Council, and except as provided in the Constitution, terminate at the time of the first Council meeting of each administration, in the month of October. There are four types of committees:

Standing Committees are responsible for the basic administrative operation of the Society — the review of applications for admission to the several membership grades, the review and publication of the technical papers and Society reports and the executive direction of Society affairs. These committees are so important that they continue to serve their functions without interruption until new committees take over.

General Committees are given the responsibility for the development of the Society's membership and the general program of activities and meetings. Also included are such important functions as the nomination of national officers and the preparation of the Society's Procedures and Policies and Constitution and By-Laws.

Technical Committees are appointed to prepare reports on scientific and engineering subjects. A large number of the technical papers published by the Society come from members of technical committees and the committees collectively produce the important Guides, Recommended and Standard Practices, as well as the periodic revised chapters of the IES Lighting Handbook.

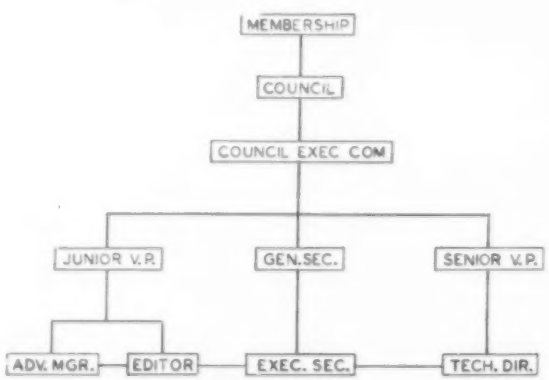
Task Committees undertake special studies, reports and programs such as for the Golden Anniversary, Light's Diamond Jubilee, and the Society's dues structure.

In addition, the Society maintains a close relationship with other technical organizations, through the appointment of an I.E.S. member to committees of these other societies. We now have such representation in 13 other organizations.

The structure of the Society management is shown in the accompanying chart. Here again, the key figure is the individual membership.

Membership — The overall operation of the Society is, in the last analysis,

(Continued on page 26A)



Operation I.E.S.

THE LIGHTING UNITS WITH
the perfect profile!

Here is ideal lighting that integrates with modern building design . . . lighting units so shallow they blend perfectly with overhead architecture. Here is fluorescent lighting that, in hundreds upon hundreds of installations across the country, is fulfilling the architect's request for clean, uncluttered lines. Here are fixtures that, because of their highly desired shallowness, have been called "the lighting units with the perfect profile"!

Appearance, however, is only a part of the reason for the success of these two outstanding Smithcraft fluorescent fixtures. Their lighting performance is highly efficient, and their availability in several combinations and lengths of lamps make them adaptable to any installation.

"Lighting units with the perfect profile" . . . designed and produced by Smithcraft to serve as architectural lighting "tools" for the men who design America's buildings.

Smithcraft DIRECTOR

An extensive yet unobtrusive "area of light" source . . . up to 37" wide and extremely shallow in appearance. Available for 2, 3, 4 or 6 lamps.

Smithcraft SHERATON

Only 3¼" deep . . . translucent plastic sides . . . a modern, trim lighting unit, ideal for low-ceiling applications. Available for 2 lamps or 4 lamps.

Send today for complete information on the Smithcraft DIRECTOR and SHERATON!

America's finest fluorescent lighting...

Smithcraft
LIGHTING DIVISION
CHELSEA 50, MASSACHUSETTS

(Continued from page 24A)

controlled by the membership. Any change in our Constitution, By-Laws, rate of dues, or any major item affecting the membership, cannot be put into effect without the majority vote of member ballots.

Officers — There are five national officers, all elected to office by the membership. The slate for their candidacy to the office is selected by the Board of Nominations which is composed of Regional representatives, one from each Region of I.E.S., who have themselves been selected by members within each Region to represent the interests and wishes of those members in national and regional matters. These five officers are:

President
Senior Vice-President
Junior Vice-President
General Secretary
Treasurer

Their names are listed on the masthead page of every issue of ILLUMINATING ENGINEERING. They constitute the personnel of the Council Executive Committee (see below). Their specific responsibilities are rather too detailed to list in their entirety in this column, but briefly:

Senior Vice-President: In addition to presiding in the absence of the President, participating in all Council and Council Executive Committee meetings and discussions, this officer during his term in office, is responsible to Council for all technical activities of the Society. He works closely with the Technical Director (permanent staff member), and is Chairman of the Technical Committee Forum, a committee made up of all of the chairmen of all of the technical committees. This is quite a job, and a very important one.

Junior Vice-President: In addition to his work as a national officer, this man also serves as Chairman of the Regional Activities Committee, an extremely busy group made up of all Regional Vice-Presidents. The work of this committee is probably the phase of Society operation of most direct importance to the membership. The men on this committee are, in effect, the "senators" representing the interests of their own Regions, of "constituents." They meet at least six times a year, usually the day before Council meeting. This officer is also the voice on Executive Council for I.E.S. publication matters, and keeps himself informed on all details of this phase also.

General Secretary: A busy man, charged with the direct responsibility to Council for all operational details of the Society, its staff, its headquarters, its headquarters equipment, necessary purchases, Minutes, and other records. Probably a better name would be "General Manager."

Treasurer: The name itself is self-explanatory, carrying the same responsibilities that the treasurer or comptroller would, in business. He must keep close touch with all financial matters of the Society, and serve as an ex-officio member of the Finance Committee. All checks are signed by the Treasurer and General Secretary, or in the absence of one of these officers, by the President.

President: Here is the "chairman of the Board" — who hears the reports of all these officers, as well as Council members, and weighs them in the light of his own many years of experience in Society operation. He presides in the chair at all Executive Council and Council meetings; interests himself in all I.E.S. matters, national, regional and local; visits once a year each of the Regions and feels the pulse of membership interests.

Final, real, and permanent responsibility for the performance of Society operation rests with the four Senior Staff members — Executive Secretary, Technical Director, Editor of Publications, and Advertising Manager. Details of their duties and of the headquarters employees who work with them, would take a full item in itself. This will be the subject of next month's column.

Council — Council meets five times a year, bi-monthly. Its administration begins October 1, its first meeting consequently held in October each year, with subsequent meetings in December, February, April and June. Its members are the five national officers, two most recent Past-Presidents, ten Regional Vice-Presidents, and six Directors (who serve a three-year term). The slate for these offices is carefully selected by the National Board of Nominations, and officers elected by secret ballot of the entire membership. They come from all parts of the U. S. or Canada, from all Regions, all branches of the lighting industry and many diversified organizations. Council acts on all matters of significance to I.E.S. affairs.

Council Executive Committee — The five national officers comprising this committee meet five times a year, in the alternate months of Council meetings (November, January, March, May and July). They consider, for either direct action or recommendation to Council, all matters placed before them by committees, individual members, headquarters staff, and others. Major problems are always referred to Council for final action, often with recommendations based on their own thorough study and discussion of the matter.

If any member desires more detailed information on Society operations, he is invited to contact Section or Chapter Chairmen, Regional Vice-Presidents, national officers, committee personnel, or write direct to A. D. Hinckley, Executive Secretary, I.E.S. Headquarters. For a complete listing of Society officers, national and local, and of committee personnel, see the October 1955 issue of I.E. and the December 1955 issue. A revision of both these lists, including all appointments since December, will be published in the April issue of I.E. — GEORGE J. TAYLOR, *General Secretary.*

Advanced Lighting Design Subject of Pittsburgh Conferences

A series of four conferences on lighting design was presented recently by the Pittsburgh Section of I.E.S. and the Electric League of Western Pennsylvania.

The two-hour sessions were held at the Duquesne Light Co. Building.

January 30 — A Discussion of Illuminating Engineering: What is a coefficient of utilization; what is a room index — John S. Frizzel, Illuminating Engineer, Pittsburgh Reflector Co.

February 6 — Illumination Calculation of Large Area Sources: applications of panel-type lighting and those sources which do not follow conventional coefficient of utilization methods. Acoustical control in luminous elements — George W. Clark, Chief Engineer, Sylvania Electric Products, Inc.

February 13 — Specifying Footcandles with Visual Aids: Scientific means of arriving at footcandle recommendations with various meters and charts — C. M. Crysler, District Engineer, General Electric Lamp Division.

February 20 — Floodlighting Design Calculations: Procedural steps in designing a floodlighting system using photometric data supplied by equipment and lamp manufacturers — Lucien T. Kight, Architectural Service, Duquesne Light Co.

Traffic Engineering Fellowships Announced at Yale University

The Yale University Bureau of Highway Traffic has announced the availability of fellowships in its Traffic Engineering course covering the next academic year of study starting September 17.

The course of graduate study is devoted to the planning and operational design of new streets, highways and terminals as well as to the regulation and control of traffic movements on existing facilities. The fellowships are to be awarded on a competitive basis to applicants who are residents of the continental United States and are graduates of an accredited school in engineering.

The five fellowships, each having its specific conditions, offer up to $2000

(Continued on page 29A)

Slimline *Lead-lag* ballasts
...for lighting economy

Know what it costs to send him up a ladder?

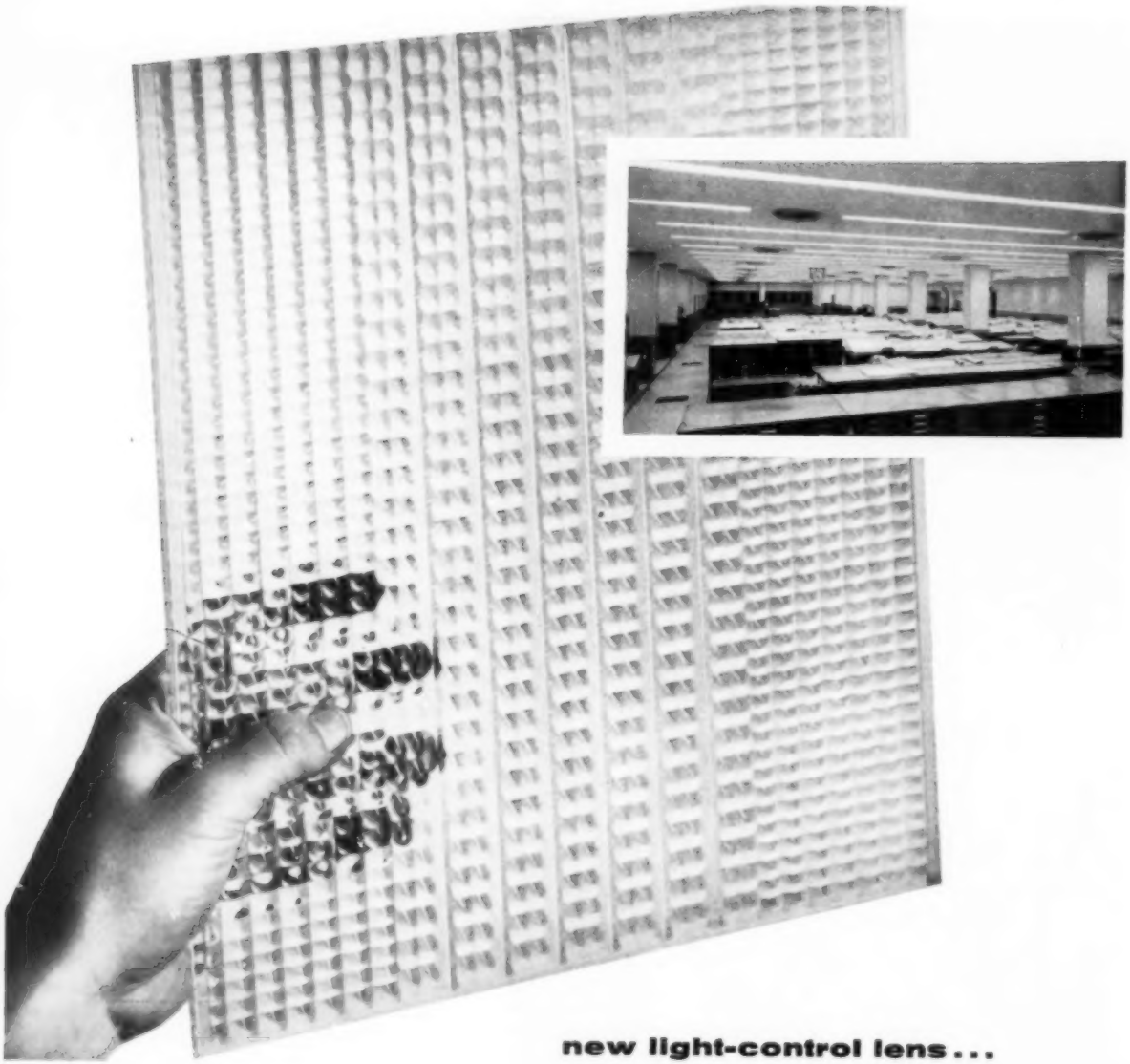
Fifty cents a round trip—maybe more. But half his effort may be unnecessary! It's this simple: If you are using series-type ballasts in your lighting fixtures and a lamp burns out, the other lamp burns dimly or goes out completely. The maintenance man has no way of knowing which lamp is defective unless he takes the time to test both. NOT so with Westinghouse slimline *lead-lag* ballasts—when one lamp burns out, the other lamp is not affected. Thus, valuable maintenance time is saved without the possibility of wasting good lamps or losing light. In addition, Westinghouse slimline *lead-lag* ballasts have a new UI core design to give you a cooler, quieter, more efficient operation.

Planning a new lighting system? Specify Westinghouse slimline *lead-lag* ballasts for real lamp replacement economy.

More information? See your Westinghouse representative or write Westinghouse Electric Corporation, Lighting Division, Edgewater Park, Cleveland, Ohio. J-04395

YOU CAN BE SURE...IF IT'S

Westinghouse



new light-control lens . . .

molded of light weight, breakage resistant

Plexiglas

When control lenses for fluorescent luminaires are molded of clear PLEXIGLAS® acrylic plastic, they provide these advantages:

Efficiency—PLEXIGLAS can be molded accurately to complex lens patterns, resulting in maximum control of light in the desired direction. In addition, PLEXIGLAS is noted for its freedom from discoloration.

Light Weight—The 12-inch-square size illustrated weighs only 16 ounces. Control lenses of PLEXIGLAS are easy to handle in installation and maintenance operations.

Breakage Resistance—The ability of PLEXIGLAS to withstand impact provides safety overhead. Strength combined with light weight makes it possible to use larger lenses and to extend control-lens lighting to larger ceiling areas.

The office lighting application shown above, at a new Western Electric Company plant, is one example of effective control in illumination with lenses molded of PLEXIGLAS. We will be glad to send you the names of fixture manufacturers who offer these lenses with their lighting equipment.

Chemicals for Industry

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

Representatives in principal foreign countries

Canadian Distributor: *Crystal Glass & Plastics, Ltd., 130 Queen's Quay at Jarvis Street, Toronto, Ontario, Canada*

(Continued from page 26A)

each. Closing date of filing applications is April 1. Those wishing information and application forms should write the Director, Bureau of Highway Traffic, Yale University, Stratheona Hall, New Haven 11, Conn.

Store Lighting Clinic Scores in New York

Excellent speakers in a full-day program covered the subject of Store Lighting in one of the annual Clinics sponsored by the New York Section of I.E.S. The meeting was held January 17 at the Sheraton McAlpin Hotel, with E. W. Beggs as Moderator.

An added attraction was the luncheon intermission, during which the Section held its I.E.S. 50th Anniversary celebration (reported on elsewhere in Telecast of this issue).

The morning program of the Clinic contained the following topics and speakers:

Development of Modern Store Lighting — E. W. Beggs, Westinghouse Electric Corp.
Fundamentals of Store Lighting—H. L. Logan, The Holophane Co.
Attractions of Store Lighting and Design — R. T. Dorsey, General Electric Co.
Color Rendition and Appraisal of Merchandise — Rollo Gillespie Williams, Century Lighting Inc.
Atmosphere: Case Histories of Store Modernization — R. C. Allison, T. Eaton and Co.

Following the luncheon Anniversary celebration, the afternoon program presented:

Store Architecture — Morris Ketchum, A.I.A., Ketchum, Gina and Sharp.
Interior Design — Morris Ketchum.
Lighting Design and Calculations — R. T. Dorsey.
Store Modernization: Case Histories — R. C. Allison.
Maintenance — R. L. Zahour, Westinghouse Electric Corp.
Future — E. W. Beggs.
Question and Answer Period.

Contributing staff to the Store Lighting Clinic were:

Lou Goren — Section Chairman.
J. W. Hamilton — Progress Chairman.
W. S. Till — Clinic Chairman.
Edwin R. Manning — Publicity Chairman.
Vernon Smith — Stage Arrangements.

The registration fee of $5.00 included the Anniversary luncheon.

PROPOSED St. Maurice Chapter of I.E.S. meets in Trois Rivieres, Quebec, January 18.

SPEAKERS at the Store Lighting Clinic presented by the New York Section, I.E.S. were, left to right: Morris Ketchum, Robert T. Dorsey, R. C. Allison, H. L. Logan, R. L. Zahour, E. W. Beggs and Rollo Gillespie Williams.

Proposed New I.E.S. Chapter Meets in Trois Rivieres, Quebec

The first meeting of the proposed St. Maurice Chapter of I.E.S. was held January 18 in the Conference Room of the Shawinigan Water and Power Co., in Trois-Rivieres, Que. The attendance of approximately 75 included architects, contractors, school officials, and industrial engineers as well as representatives from utilities, local manufacturers and distributors.

Jean Lafontaine, I.E.S. Local Representative in Trois Rivieres and Chairman of the meeting, outlined the objectives of the Society. He then introduced Joe Thomas, Canadian Regional Vice-President, who spoke of the I.E.S. Golden Anniversary this year and of progress in other Regions.

Final speaker was Victor Labbe, of J. A. Wilson Lighting and Display, who discussed luminous ceiling design.

ABOUT PEOPLE

Four new members were elected to the Board of Directors of Day-Brite Lighting, Inc., St. Louis, Mo., at the annual meeting of stockholders, January 23. They are **James F. Whitehead, Jr.,** Vice-President in Charge of Sales; **O. C. Klingsick,** Vice-President in Charge of Production; **Walter L. Rehfeld,** Vice-President, Mercantile Trust Co.; **Gordon Scherck,** Partner, Scherck Richter Co. Re-elected to the 7-man board were **D. J. Biller,** formerly President and now Chairman of the Board; **O. W. Klingsick,** now President, who was formerly Executive Vice-President and Treasurer;

(Continued on page 37A)

HOW CONSULTING LIGHTING ENGINEERS PROFIT FROM MEMBERSHIP IN I.E.S.

Consulting engineers doing lighting specification work gain as much or more than any other segment of the vast lighting industry from their membership in the Illuminating Engineering Society. Aside from their closer affiliation in I.E.S. with key lighting people in their locality and first-hand information about new lighting jobs in the making, they have other definite advantages which aid in their professional development and prestige . . . improve their personal knowledge and ability to keep up with this rapidly-changing field.

Monthly copies of ILLUMINATING ENGINEERING, the Society's official journal, give members new lighting techniques and applications as well as technical developments . . . provide a monthly refresher course in good lighting obtainable nowhere else.

Monthly local meetings, Regional and National Conferences, build recognition and closer associations locally, broaden business reputation through several states and even nationally. Programs bring speakers of note on subject of lighting, new techniques, new applications; clinics and Study Groups.

OPEN TO MEMBERS ONLY . . . "My Most Interesting Lighting Job," annual international lighting job competition gives opportunity for local, regional and national recognition for outstanding work in lighting, builds business standing of winners at any level.

I.E.S. Technical Committees have since 1906 been the boundless source of major lighting developments. Work in one or more of these essential groups by qualified members provides the opportunity for service to the lighting industry . . . for taking an active, personal role in lighting progress.

Write for membership information

ILLUMINATING ENGINEERING SOCIETY

1860 Broadway New York 23, N.Y.

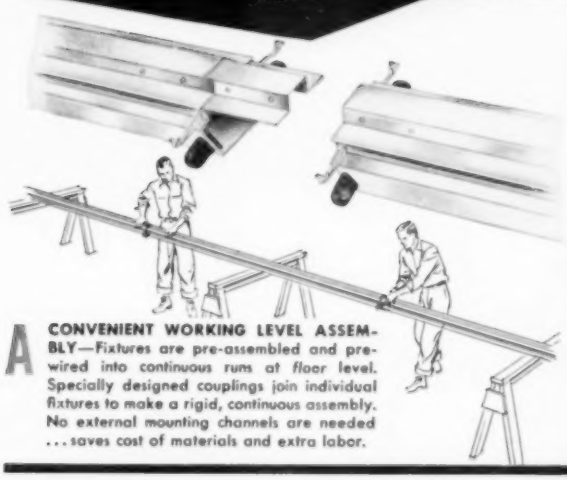
THIS IS THE GARCY *Speed-line*® SYSTEM optional at no extra cost with Garcy Visualier and Gar-See-Lite Fixtures

School gets premium lighting at saving of $4482 with GARCY *Speed-line*®

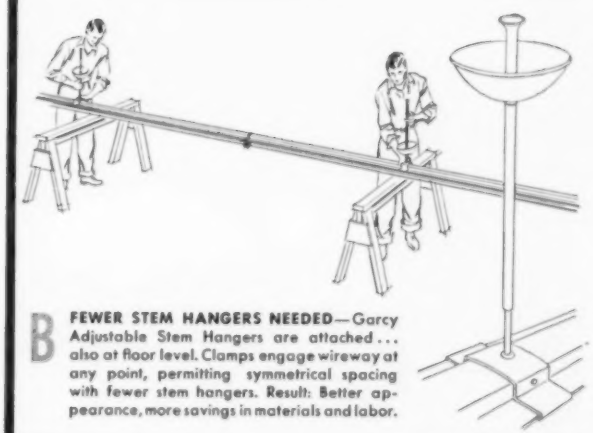
The potential savings of the Garcy *Speed-line* System were well known to E. F. Klingler & Associates, architects, who supervised the job of relighting the Eau Claire Senior High School. All bidders for the lighting contract were invited to submit an alternate figure based on *Speed-line* savings. In the successful bid, *Speed-line* savings were figured at $4482 . . . a cost reduction representing *more than half the installation labor costs*, plus the elimination of external mounting channels. This saving permitted the installation of the finest in school lighting . . . Garcy Visualiers . . . at far less than the cost of ordinary fixtures.

Learn how Speed-line *is reducing installation labor costs . . . in some cases as much as 90% . . . on continuous-run lighting.*

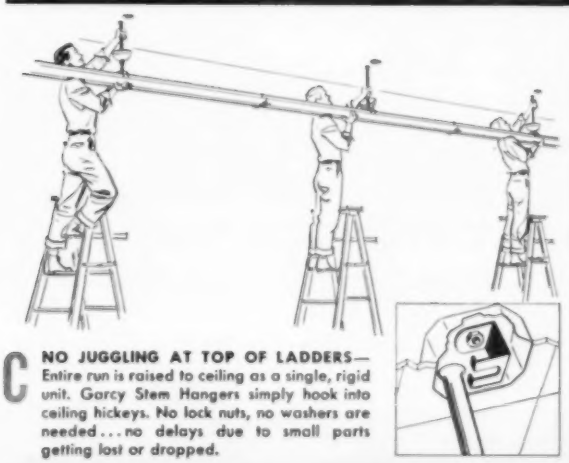
Send today for Bulletin 551-L



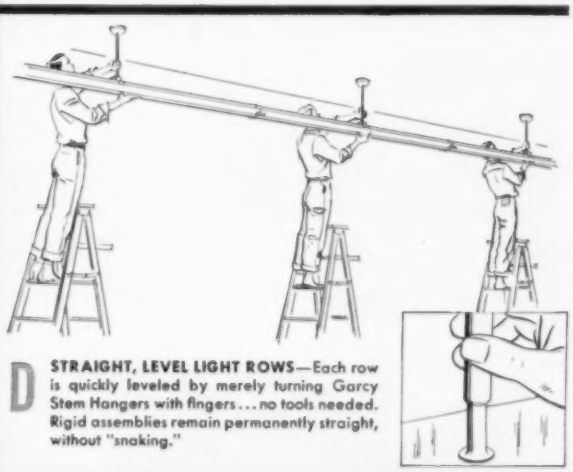
A CONVENIENT WORKING LEVEL ASSEMBLY—Fixtures are pre-assembled and pre-wired into continuous runs at floor level. Specially designed couplings join individual fixtures to make a rigid, continuous assembly. No external mounting channels are needed . . . saves cost of materials and extra labor.



B FEWER STEM HANGERS NEEDED—Garcy Adjustable Stem Hangers are attached . . . also at floor level. Clamps engage wireway at any point, permitting symmetrical spacing with fewer stem hangers. Result: Better appearance, more savings in materials and labor.



C NO JUGGLING AT TOP OF LADDERS—Entire run is raised to ceiling as a single, rigid unit. Garcy Stem Hangers simply hook into ceiling hickeys. No lock nuts, no washers are needed . . . no delays due to small parts getting lost or dropped.



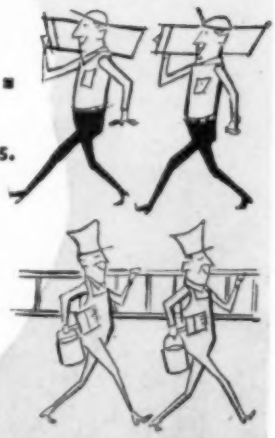
D STRAIGHT, LEVEL LIGHT ROWS—Each row is quickly leveled by merely turning Garcy Stem Hangers with fingers . . . no tools needed. Rigid assemblies remain permanently straight, without "snaking."

Send today for Bulletin 551-L

GARCY *Quality by Design*

GARDEN CITY PLATING & MFG. CO., 1742 N. Ashland Ave., Chicago 22, Ill. In Canada: Garcy Co. of Canada, Ltd., 191 Niagara St., Toronto

THE LIGHTS THAT GO IN WHEN THE PAINTERS GO OUT...



No On-Job Storage. No Paint-Spattered Fixtures. 50% Savings on installation costs.

Gibson ORTHO Fixtures need not be stored on the job where they're in the way of workmen and in danger of damage. Actually, Gibson ORTHO Fixtures can be delivered to the job the day before occupancy, because each fixture simply snaps into place in a matter of seconds, just as it comes from the box —sparkling clean, factory-fresh.

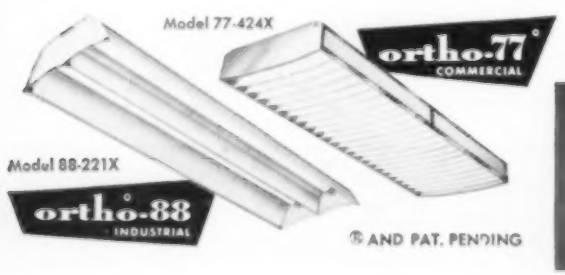
If you're interested in better lighting with savings of more than 50% on installation costs, then you really ought to know more about the Gibson ORTHO Line for industrial and commercial applications. Drop us a line. We'll send you the whole story.

1. WIRED ON THE FLOOR • A special channel (UNI-RACE) of telescoping 4' or 8' sections is assembled and wired on the floor, then lifted as a unit and mounted directly on joists, I-beams or stems. Saves hours of labor.

2. READY FOR THE FIXTURES • The UNI-RACE in place showing the built-in receptacles at 48" intervals. While the building is under construction, it will serve as a source of power for tools and temporary lighting.

3. SNAP—AND IT'S UP! • When the painters have left, the fixtures can be delivered to the building and snapped into place as fast as they are unboxed. Each fixture has a built-in plug which engages the receptacle in the UNI-RACE. Fixtures align themselves automatically.

4. VARIABLE SPACING • Fixtures may be installed in continuous rows or spaced at intervals of 4, 8, 12 or more feet. Units may be added, removed or rearranged any time without tools. Special "fill-in" sections close the UNI-RACE where no fixtures are mounted.



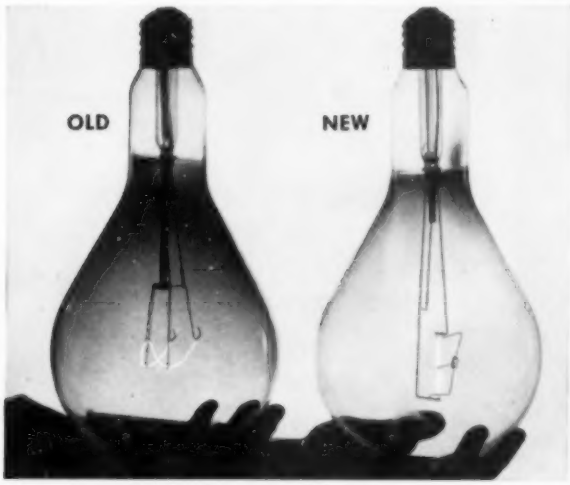
® AND PAT. PENDING

Gibson LIGHTING

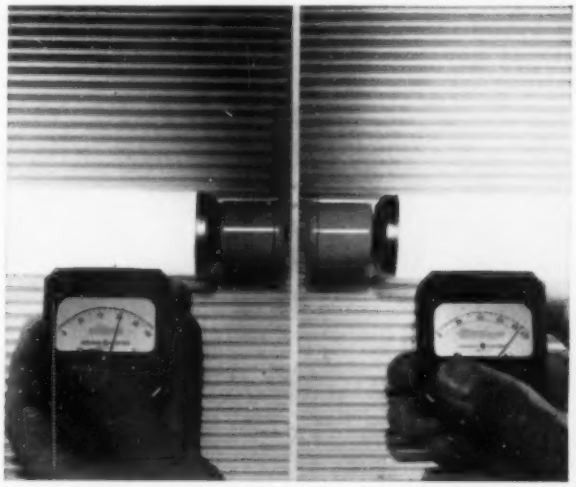
GIBSON Manufacturing Co.

1919 Piedmont Circle, N.E. Atlanta 9, Georgia

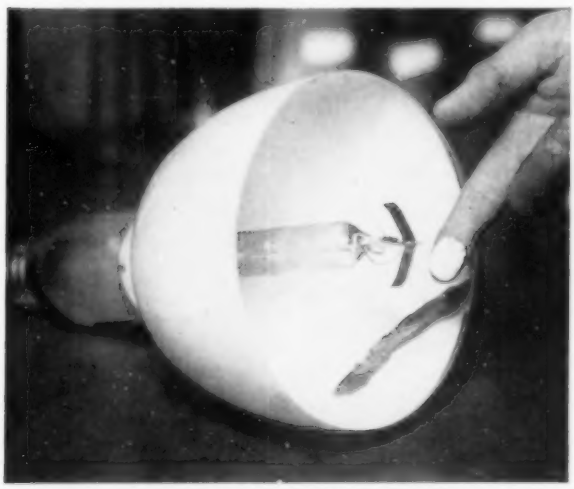
G-E LAMPS GIVE YOU MORE FOR ALL YOUR LIGHTING DOLLARS



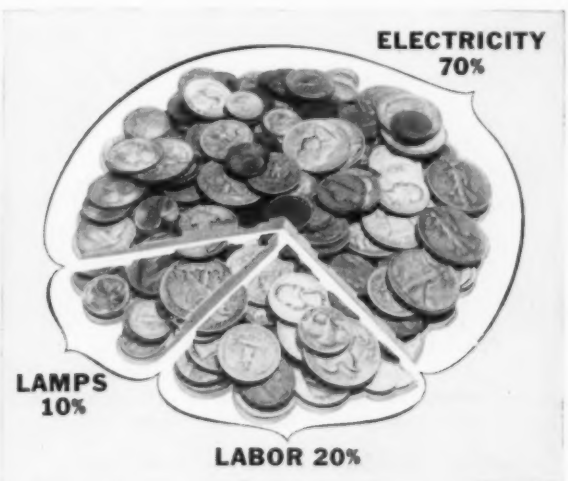
IN FILAMENT LAMPS—Bonus Line (above right), with the most important filament improvement in 42 years, reduces bulb blackening and offers up to a 15% bonus of light. This is worth about the entire cost of the lamp itself.



IN FLUORESCENT LAMPS—The General Electric High Output fluorescent (above right) gives you 40% more light than any other fluorescent lamp. Cuts costs by providing more light with equal number of fixtures. Now available in De Luxe Cool White.



IN MERCURY LAMPS—A new double-duty phosphor coating acts as a reflector and also improves the color of light. Makes the G-E 400 RC-1 your best bargain for most indoor mercury uses.



PIE CHART shows what the average user pays to operate his light bulbs. It shows how even a 1% saving in operating costs is worth as much to you as a 10% reduction in lamp costs.

How General Electric lamp developments keep down the big items in your lighting costs

MORE light for your money is the constant aim of General Electric lamp research. As the pie chart above shows, when you pay for a lamp, you've paid only one tenth the total cost you pay to operate the lamps. Better *performance* in your lamps is the common sense way to reduce your lighting costs.

Again in 1955, General Electric produced many new lamps to bring you more light at lower cost.

To find out how you can use one or more of these developments to reduce *your* business costs or make *your* business more profitable in 1956 write for: *Report to Lamp Users 1956.* Large Lamp Department, General Electric, Dept. IE-3, Nela Park, Cleveland 12, Ohio.

Progress Is Our Most Important Product

GENERAL ELECTRIC

ADJUSTO SILVER-SPOT #116-#117

TWO NEW Silver-spot

INCANDESCENT SILVERED BOWL

DOWNLIGHTS

that actually provide

LIGHT AT THE LOWEST COST PER FOOTCANDLE*

Placed side-by-side with ten other downlighting devices, and tested under identical conditions the new Silver-Spot units provided light at over-all cost per footcandle from 33% to 92% less than other units tested.

This saving makes it possible to pay for Silver-Spot equipment out of operating savings.

THE BIG BONUS FEATURE

All Silver-Spot and Silver-Dot units completely eliminate glare of the incandescent filament. The exclusive Silvray Silvered bowl principle conceals the filament in an efficient mirror reflector—processed on the lamp itself. It puts light where you want it and not in the eyes of customers and employees.

ADJUSTO SILVER-SPOT—#116-#117

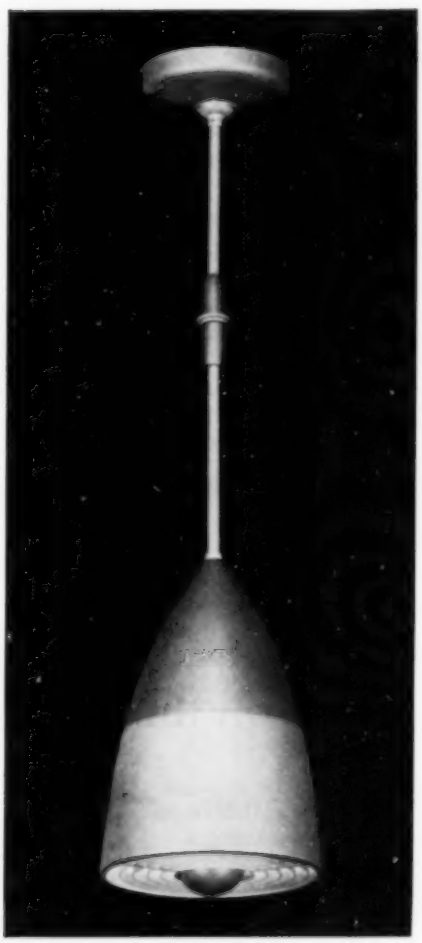
A recessed unit with full 360° rotation and 70° vertical swivel. Available with Coloray reflectors for red, blue or gold color effects. Completely wired.

PENDANT SILVER-SPOT—#114-#115

In gleaming, new exterior color finishes of gold, aluminum or black and two-toned combinations. Also with interchangeable colored reflectors for red, blue or golden light.

*Let us prove it!

The complete test described above is available on request. The method of test and the results are completely explained. All Silver-Spot and Silver-Dot units were included. Request this report on your letterhead or from your nearest Silvray Representative or Authorized Distributor.



PENDANT SILVER-SPOT #114-#115

SKYLIKE LIGHTING, INC.

A SILVRAY ASSOCIATED COMPANY

RKO Bldg., New York • Bound Brook, New Jersey

Recessed luminaires for the Royal Castle hamburger stands in the Miami, Florida, area by the Wakefield Company, Vermilion, Ohio. "Lucite" acrylic resin extruded by Southern Plastics Company, Columbia, S. C.

Better looking, better lighting

with diffusing panels of Du Pont LUCITE®

Everything possible was done to make the recently constructed Royal Castle hamburger stands truly spots "fit for a king." This called for a happy blending of operating efficiency and beauty.

When it came to lighting, the selection was an obvious one . . . the "Castles" get appealing lighting both indoors and out with diffusing panels of extruded "Lucite."

Diffusing panels of "Lucite" acrylic resin transmit optimum light without specular glare or shadow. They are strong, durable, free from discoloration, and dimensionally stable. Installation is a simple matter. Panels of "Lucite" are light in weight and easy to handle . . . maintain their clarity and beauty.

Du Pont "Lucite" can be formed readily into desired shapes and is available in a wide range of transparent and translucent colors.

Send for free, new booklet. This new 12-page illustrated booklet describes all the latest property and application data on "Lucite" acrylic resin for lighting. For your free copy, write to E. I. du Pont de Nemours & Co. (Inc), Polychemicals Dept., Room 283, Du Pont Building, Wilmington 98, Delaware.

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

This "Quality Controlled" label may be used only by qualified extruders of Du Pont "Lucite" acrylic resin. It assures the lighting industry that the extruded material conforms to standards for low shrinkage and uniform caliper established by E. I. du Pont de Nemours & Co. (Inc.).

Quality Controlled

CEILING UNLIMITED!

Unlimited life—plus life-long economy of operation—are just a few of the advantages of an all-aluminum **HONEYLITE** ceiling. Made of HEXCEL aluminum honeycomb, this revolutionary new illuminated ceiling will never crack from heat or discolor with age. As functional as it is beautiful, **HONEYLITE**'s thousands of ¼-inch hexagonal cells diffuse light evenly into every corner of the room with less than 15% loss in light "put-through." This means fewer lighting units and lower installation and operating costs.

HONEYLITE panels are available in standard sizes for easy installation in standard T-bar suspension systems. Easily removable, relamping and maintenance work is reduced to a minimum.
Specify **HONEYLITE** in your next installation—for these additional reasons you'll be glad if you do:

- ★ 45° and/or 60° light cut-off provides effective shielding
- ★ Non-flammable and UL approved
- ★ Weighs only two ounces per square foot
- ★ Free circulation of air prolongs life of light units
- ★ Provides lowest surface brightness obtainable
- ★ Has noise reduction coefficient of .46
- ★ Non-static and dust resistant
- ★ May be cleaned with ordinary vacuum brush attachment

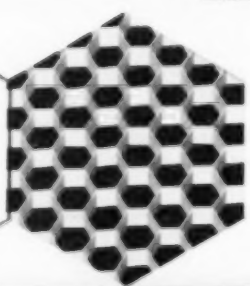
One of the most amazing products to come out of the jet age, Hexcel aluminum and glass-fabric honeycomb combines lightness with strength to give the F-100 Super Sabre maximum speed, maximum striking power. The secret is sandwich construction. When "sandwiched" between two sheets of lightweight metal, Hexcel honeycomb core produces a structural material with the highest strength-to-weight ratio ever developed!

In aircraft construction, in spandrel panels for the building industry, and now in louverall lighting—Hexcel aluminum honeycomb is finding new uses every day! If you think it could solve an engineering or design problem of yours, wire or write to

HEXCEL PRODUCTS, INC.,
951 61st St., Oakland 8, Calif.

NATIONAL HOUSING CENTER, WASHINGTON, D. C. — AUBINOE, EDWARDS AND BARRY, A. I. A.

HONEYLITE (shown at right actual size) installation is simple, inexpensive. For full ceilings, aluminum T-bars are used to suspend **HONEYLITE** panels below lighting units. **HONEYLITE** is also ideal for use in troffers and lighting fixtures.



HONEYLITE®

Light-diffusing acoustical aluminum honeycomb

A development of **HEXCEL PRODUCTS INC.**

Producers of HEXCEL aluminum honeycomb – the wonder material

(Continued from page 29A)

Louis J. Portner, Secretary and General Counsel. **W.S. Coffing,** formerly Vice-President and Controller, was appointed Vice-President and Treasurer.

G. Dallas Rand has been appointed to the newly created position of manager, government relations of the Lighting Division of Sylvania Electric Products, Inc., to coordinate the activities of the various regional and district sales managers in the sale of lighting products to the government. Mr. Rand will make his office at 2520 Oakville St., Alexandria, Va.

George Gill announces the formation Gill Southern Associates, specialized lighting consultants at 1805 Alamanda Drive, Keystone Point, North Miami, Fla.; mailing address, P. O. Box 775, North Miami.

Northern Light Co., Milwaukee, Wis., announces the election of **Roy O. Kallenberger** to the board of directors. Mr. Kallenberger is a professional consulting engineer and an instructor in Illuminating Engineering at Marquette University.

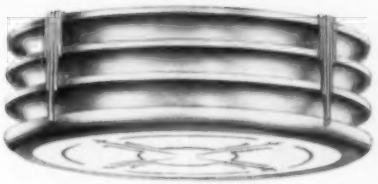
At the 62nd Annual Meeting of the American Society of Heating and Air-Conditioning Engineers, January 23-25 in Cincinnati, **John W. James** was installed as President of the organization. Mr. James, vice-president of research, McDonnel and Miller, Inc., Chicago, succeeds retiring President **John E. Haines,** Minneapolis-Honeywell Regulator Co. Other officers installed are **Peter B. Gordon,** first vice-president; **Elmer R. Queer,** second vice-president; and **Ralph A. Sherman,** treasurer.

Moe Light Division of Thomas Industries Inc., Louisville, Ky., has reorganized its sales organization and has promoted five former regional managers to the newly-created posts of divisional sales managers. The five men and their divisions are **Roy Vershure,** Great Lakes; **Sam Levaur,** Eastern; **V. L. Wrye,** Southeastern; **A. O. Grotenhuis,** Western; and **E. A. Lea,** Midwestern.

The appointment of **Lloyd Durfee, Jr.,** as commercial lighting engineer has been announced by Sylvania Electric Products, Inc. In his new position, Mr. Durfee will be located at the company's Wheeling, West Va., manufacturing plant. Prior to this position, he was with the Blackstone Valley Gas and Electric Co. in New England, as a lighting engineer.

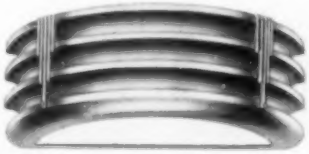
Edwin R. Maize, Jr., has recently joined the General Electric Co. Large

(Continued on page 38A)



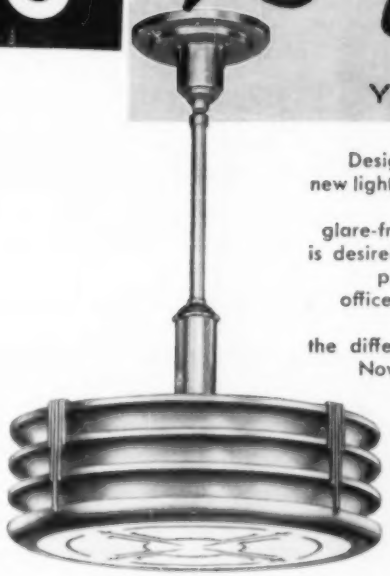
CEILING LOUVER
No. 8040, Pewter and Gold. Etched Albatone Bottom Glass. Sizes 12" Diameter to 24".

HALF ROUND LOUVER POCKET
No. 8051, Pewter and Gold. Albatone Bottom Glass. Sizes 10" Diameter to 16".



5 Lighting ideas YOU CAN USE...

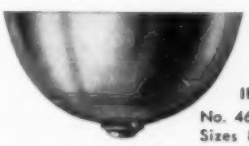
Designed for modern beauty and new lighting efficiency. Recommended wherever a high intensity of glare-free incandescent illumination is desired. Ideal for commercial and public building use in schools, offices, lobbies, conference rooms etc. Your customers can SEE the difference when it's Lighting by Novelty! Write for new catalog.



PENDANT LOUVER
No. 8045, Pewter and Gold. Etched Albatone Bottom Glass. Sizes 14" Diameter to 24".

Section showing Reflector for 300 to 500 watt lamp

INDIRECT POCKET REFLECTOR
No. 8381, Pewter. Equipped with Asymmetric Mirrored Glass Reflector. Size 14" diameter.



INDIRECT POCKET
No. 4614, Pewter and Gold. Sizes 8" and 12" width.

Designers and Manufacturers . . . Since 1905

THE NOVELTY LIGHTING CORP.

2490 EAST 22nd STREET CLEVELAND 15, OHIO

AT NO EXTRA COST

SLOTTED-NECK construction is an original ABOLITE development. It costs you no more than ordinary reflectors.

ABOLITE SLOTTED-NECK lighting fixtures provide longer lamp life because lamps operate at cooler temperatures.

You can have ABOLITE All-White

SLOTTED-NECK ABOLITE fixtures stay cleaner longer. Dust and grime is forced through ventilator slots by continuous convection currents.

ALL-WHITE finish (inside and outside) gives you a modern, efficient appearing lighting fixture which compliments contemporary architecture.

slotted-neck reflectors

Actual tests show that ABOLITE ALL-WHITE SLOTTED-NECK lighting fixtures give 36% more illumination than ordinary reflectors after 12 weeks continuous use. In addition, modern ABOLITE fixtures provide 7% more uplight, and a 1000 watt bulb operates 40°F cooler in a SLOTTED-NECK ABOLITE reflector.

All these features mean more and better light with an absolute minimum of maintenance . . . and *at no extra cost!*

ABOLITE Lighting DIVISION
THE JONES METAL PRODUCTS CO.
WEST LAFAYETTE, OHIO

(*Continued from page 37A*)

Lamp Department at Nela Park, as Retail Sales Grocery Specialist. Mr. Maize was formerly a sales executive with Westinghouse Electric's Lamp Division in Bloomfield.

Don F. Feerer, formerly Vice-President and General Manager of Staleup, Inc., Kansas City, Mo., outdoor advertising company, has been named General Manager of the Electrical Advertising Division of the Federal Sign and Signal Corp., Chicago, Ill.

Charles H. Goddard, I.E.S. Past-President, has been named manager of Thomas A. Edison Inc.'s Voicewriter Division. Mr. Goddard joined the company last year as assistant manager of the division.

Ruby Lighting Corp., Los Angeles, is currently negotiating for a building of approximately 60,000 square feet and 25,000 square feet of parking area which is to be used for future expansion. The organization is now under the guidance of **Albert Jassim.**

The Miller Co., Meriden, Conn., has announced the appointment of **E. S. Coe** as Eastern Regional Sales Manager with headquarters in Meriden. Mr. Coe began his association with the company in 1938 as field engineer. Most recently he has been Field Sales Engineer for eastern New York in Schenectady, N. Y.

William J. Gorman has been appointed Advertising and Sales Promotion Manager of Jefferson Electric Co., Bellwood, Ill., succeeding **Joseph J. Archibald,** who will serve as Sales Manager of the company's newly formed Consumer Products Division. Mr. Gorman was formerly Merchandising Manager.

BOOKS AND PAMPHLETS

*Books whose reviews are marked * are available for inspection at the I.E.S. Headquarters, Technical Department.*

***Illuminating Engineering Course,** by H. Kijl, published by N. V. Philips' Gloeilampenfabricken, Eindhoven, Holland, 1955, illustrated, cloth-bound, $4.50. Available in the United States from Elsevier Press, Inc., 2330 Holcombe Blvd., Houston 25, Texas, or direct'y from the publishers in Eindhoven, Holland.

As stated by the author in the preface, "The contents of this booklet are con-

(*Continued on page 40A*)

Certified Lighting for a Better America

ELECTRICAL CONTRACTORS, WHOLESALERS, LIGHT & POWER COMPANIES!

This program is sponsored by all these member companies of the Industrial and Commercial Lighting Equipment Section of the National Electrical Manufacturers Association to help you increase your sales.

These manufacturers stand ready collectively and individually to cooperate with you in every possible way to help you get the most out of this CERTIFIED LIGHTING PROGRAM. Call on them!

Abolite Lighting Division
The Jones Metal Products Co.
Amplex Corp.
Art Specialty Co.
Benjamin Electric Mfg. Co.
M. Black Mfg. Co.
Columbia Electric & Mfg. Co.
Compco Corp.
Curtis Lighting, Inc.
Day-Brite Lighting, Inc.
Eastern Fixture Co., Inc.
Fluores-O-Lite Co.
The Frink Corp.
Fullerton Mfg. Corp.
Garden City Plating & Mfg. Co.
General Lighting Products Co.
The Edwin F. Guth Co.
Holdenline Co.
Holophane Co., Inc.
The Kirlin Co.
Lighting Products, Inc.
Litecontrol Corp.
Markstone Mfg. Co.
The Miller Co.
Morlite Equipment Co.
Neo-Ray Products, Inc.
Overbagh & Ayres Mfg. Co.
Pittsburgh Reflector Co.
The Pyle National Co.
Quadrangle Mfg. Co.
Ruby-Philite Corp.
Silvray Lighting, Inc.
Smithcraft Lighting Div. of A. L. Smith Iron Co.
Smoot-Holman Co.
Solar Light Mfg. Co.
The Spero Electric Corp.
Sun-Lite Mfg. Co.
The Swivelier Company
Sylvania Electric Products, Inc.
Kurt Versen Co.
The Wakefield Company
Westinghouse Electric Corp.
Wheeler Reflector Co.
R. & W. Wiley, Inc.
The Wiremold Co.

Sell Up with PLUS FEATURES and NATIONAL LIGHTING STANDARDS

Now, there is a New, Easier Way to Sell More Jobs...Better Jobs...Bigger Profit Jobs!

Sell up to the standards... not down to a price! You do this and you SELL up the quality, too, when you use the tested Certified Lighting method of selling! Show the prospect the PLUS FEATURES CHECK LIST! It's the easiest way to sell *more* lighting... extra lighting that means bigger profits to you... and *much greater satisfaction for the customer!* Show the prospect the Certified Certificate. It's the easiest way to uphold the job — to keep it from being cut. That's why this certificate is so important. You can and will deliver the kind of lighting they need. It all adds up to easier selling... Write for free booklet.

Is Certified Lighting in Operation in Your Area?

This program is operated locally under the joint sponsorship of all electrical groups. If your area is listed below, get in touch with your local group... otherwise, write National Lighting Bureau.

Boston, Mass. Charlotte, N.C.
Chattanooga, Tenn.
Cincinnati, Ohio Detroit, Mich.
Los Angeles, Cal.
Providence, R.I.
Rochester, N.Y. San Diego, Cal.
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Certified Lighting for a Better America

R1192

Certified Lighting

NATIONAL LIGHTING BUREAU, 155 East 44th Street, New York City, Sponsored by the Industrial and Commercial Lighting Equipment Section of NEMA the National Electrical Manufacturers Association

It's *EXTRUDED* Acrylic Sheet

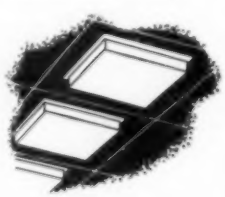
It's GERLITE

Quality Controlled

Brings you new advantages— extra strong, forms more easily, costs less!

Just imagine Acrylic sheets that are stronger and lower in cost than you've ever seen — sheets that can be deep drawn to shapes never before considered practical . . . and you begin to get an idea of what you can do with Gerlite. Extrusion technique makes Acrylic sheets seem almost a new material for all lighting and sign applications!

Years of Gering experimental work are behind *extruded* Gerlite. Years of testing in lighting and sign applications prove Gerlite meets every requirement! Sheets are available clear or colored, to 54" wide, to .125" thick, any practical length. Gerlite can be painted or silk-screened easily with existing paints now in use. Stands up to weather, gives long dependable service. Why not write now for full information and prices!



GERLITE

EXTRUDED ACRYLIC SHEET

GERING PRODUCTS, INC.
KENILWORTH, N. J.

Mail Coupon Today!

GERING PRODUCTS INC.
Kenilworth, N. J.

Please send me full information on Gerlite.

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Company _____

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(Continued from page 38A)

fined mainly to functional lighting, *i.e.* lighting for a definite purpose, its foremost aim being to provide the necessary insight for the engineer or technician who, whether professionally or because of his official or industrial position, finds himself confronted with lighting problems, and to give him suitable guiding principles to follow. The method of dealing with the subject-matter has been so chosen that even readers having a limited technical background will be able to assimilate the material."

Among the subjects treated are: Light, The System of Measurements used in Illuminating Engineering; The Inverse Square Law and the Cosine Law; Reflection, Transmission and Absorption; The Measurement of Light; The Visual Sense; Sensory Perception; Illumination and the Work; The Quality of Illumination; The Colour of Artificial Light; Lamps; Electric Gear for Gas-Discharge Lamps; Gas-Discharge Lighting Installations; Requirements to be Imposed on a Lighting System; Seeing; General Lighting Systems; The Coefficient of Utilization; Irregularities in General Lighting; Local Lighting; Lighting-Fittings; and Planning an Installation. Included in the last chapter are 170 questions and answers on practical problems. They are graded to follow the course and are listed by chapter number for ready reference.

This book is one of the "Light and Lighting" series in the Philips' Technical Library.

Engineering Drawing and Geometry, by Randolph P. Hoelscher and Clifford H. Springer, published by John Wiley & Sons, 440 Fourth Ave., New York 16, N. Y. 520 pages. $8.00.

Intended for engineers, rather than draftsmen, this book covers the tools and techniques of visual communication, including the problems of dimensioning and shop practice, an interchangeable design covering geometrical and positional tolerancing, and axonometric projection as well as standard isometric and oblique. There are over 1000 illustrations and 60 tables.

Mr. Hoelscher is a professor and head of the department of general engineering at the University of Illinois, and Mr. Springer is a professor in the same department.

Light, an Aid to Sight (form B-562), Better Light Better Sight Bureau, 420 Lexington Ave., New York 17, N. Y. $2.00 per hundred; $1.50 for quantities of 1000 and more.

This 8-page folder is planned for use by electric light and power companies in

disseminating information on the application of good lighting principles to seeing tasks in the home. Pocket-sized and printed in two colors, the folder was designed to be suitable for distribution to optometrists and ophthalmologists, for use at meetings of service club and civic groups and for availability to schools. It was prepared by the Home Lighting Education Committee of the BLBS Bureau.

Basic Guide on Store Modernization, available from the Store Planning Center of the Store Modirenization Institute, 5 Middlesex Road, Darien, Conn. $10.

This guide is directed at appliance store owners who want to modernize their stores and showrooms and would like advice on where to begin and how to go about it. It was prepared with the assistance of the architect and engineer consultants of the Institute's new Store Planning Center.

The purpose of the guide is to show the small store owner how to gather facts on what he has at present; how to organize his ideas on what he wants to accomplish; and how to avoid some costly mistakes for lack of a systematic method of organization. The Basic Guide kit includes a detailed questionnaire to help the retailer record the facts about his present store layout and merchandising set-up, with instructions and examples for taking measurements of the store areas; for checking the condition of his present fixtures and other equipment and the physical construction of his store. When the store owner has organized his modernization ideas, he can turn the material over to a local architect or contractor for sketches, plans, blueprints and estimates, according to the announcement.

I Want to Know About the Electric Industry, 1955-1956 Edition. Published by the Edison Electric Institute, 420 Lexington Ave., New York 17, N. Y.

Eighth in a series begun in 1948, this 32-page booklet takes the form of 29 questions concerning various aspects of the electric industry, tracing the trend of its progress and growth. Included in the picture are revised data on capacity and production, the financial investments on which growth is based and the prospects for continued future expansion. The utilization of atomic energy in the production of electricity — its present status and future possibilities — is discussed in some detail, including the problems involved in the transition from the use of ordinary fuels to nuclear energy.

NEW MEMBERS

At the meeting of the I.E.S. Council held at New York, N. Y. on February 9, 1956, the following were elected to membership. Names marked * are transfers from Associate Member grade.

ALAMO CHAPTER

Associate Member:

Smith, W. S., Square D Co., San Antonio, Texas.

ARKANSAS CHAPTER

Associate Member:

Byles, B. A., Westinghouse Electric Corp., Little Rock, Ark.

BLUENOSE CHAPTER

Member:

Phillips, W. J., Nova Scotia Light & Power Co. Ltd., Halifax, N. S.

BRITISH COLUMBIA SECTION

Member:

*Hutchings, J. G., Neolite Ltd., Vancouver, B. C.

CENTRAL NEW YORK SECTION

Associate Members:

Flanagan, G. T., Niagara Mohawk Power Corp., Syracuse, N. Y.

Kalil, F. A., Niagara Mohawk Power Corp., Syracuse, N. Y.

Loos, J. E., Niagara Mohawk Power Corp., Syracuse, N. Y.

(*Continued on page* 42A)

Art Metal Elipticone Lighting dramatically invites sales

ART METAL ELIPTICONE LIGHTING creates a buying atmosphere in this contemporary super market.

ELIPTICONE versatility offers:

- Unawareness of light source
- Low initial cost and maintenance
- Color-accenting through color lamps
- High-lighting displays and promotions

THE ART METAL COMPANY • CLEVELAND 3, OHIO

(Continued from page 41A)

CENTRAL OKLAHOMA CHAPTER

Associate Member:

Ramsey, R. C., The R. C. Ramsey Co., Oklahoma City, Okla.

CHICAGO SECTION

Member:

*Harvey, G. C., General Electric Co., Danville, Ill.

Associate Members:

Callaghan, W. T., Steber Mfg. Co., Broadview, Ill.
Gowgiel, A. M., Jr., Curtis Lighting Inc., Chicago, Ill.
Jones, R. D., Schmidt, Garden & Erikson, Chicago, Ill.
Levine, Shirley, Electro Silv-A-King Corp., Chicago, Ill.
Reynolds, J. E., Electro Silv-A-King Corp., Chicago, Ill.
Stauffer, R. L., General Electric Co., Chicago, Ill.
Whitmore, W. R., General Electric Co., Chicago, Ill.

CLEVELAND SECTION

Associate Members:

Bailey, E. V., The Union Metal Mfg. Co., Canton, Ohio.
Schomer, M. J., 5151 Warrensville Center Road, Maple Heights, Ohio.

CONNECTICUT SECTION

Associate Member:

Hamilton, R. J., John P. Legnos Associates, Hartford, Conn.

CORNHUSKER CHAPTER

Associate Member:

Hacke, Day, Nebraska-Iowa Electrical Council, Omaha, Nebr.

EASTERN PENNSYLVANIA SECTION

Associate Members:

Darkes, A. C., Duro Test Corp., North Bergen, N. J.
Haberstroh, E. J., 836 Elm St., Reading, Pa.

FLORIDA SECTION

Associate Members:

Dolphy, J. T., General Electric Supply Co., Tampa, Fla.
Moos, P. H., Frank Moos & Son, Tampa, Fla.
Williers, A. R., Williers Electric Co., Tampa, Fla.

FOREIGN NON-SECTION

Member:

Croft, Ronald, Corporation of Glasgow, Glasgow, C. 1., Scotland.

Associate Member:

Berson, M. L., 205 North Street, Leeds, Yorkshire, England.

GOLDEN GATE SECTION

Members:

*Howatt, S. E., Pacific Gas & Electric Co., San Francisco, Calif.
*Schiewe, N. A., Pacific Gas & Electric Co., San Rafael, Calif.

Associate Members:

Dunlop, D. R., Industrial Testing Laboratories, Berkeley, Calif.
Thompson, A. E., Prescolite Mfg. Co., Berkeley, Calif.
Vierra, Miss Bernice, 1298 Haight St., San Francisco, Calif.

HEART OF AMERICA SECTION

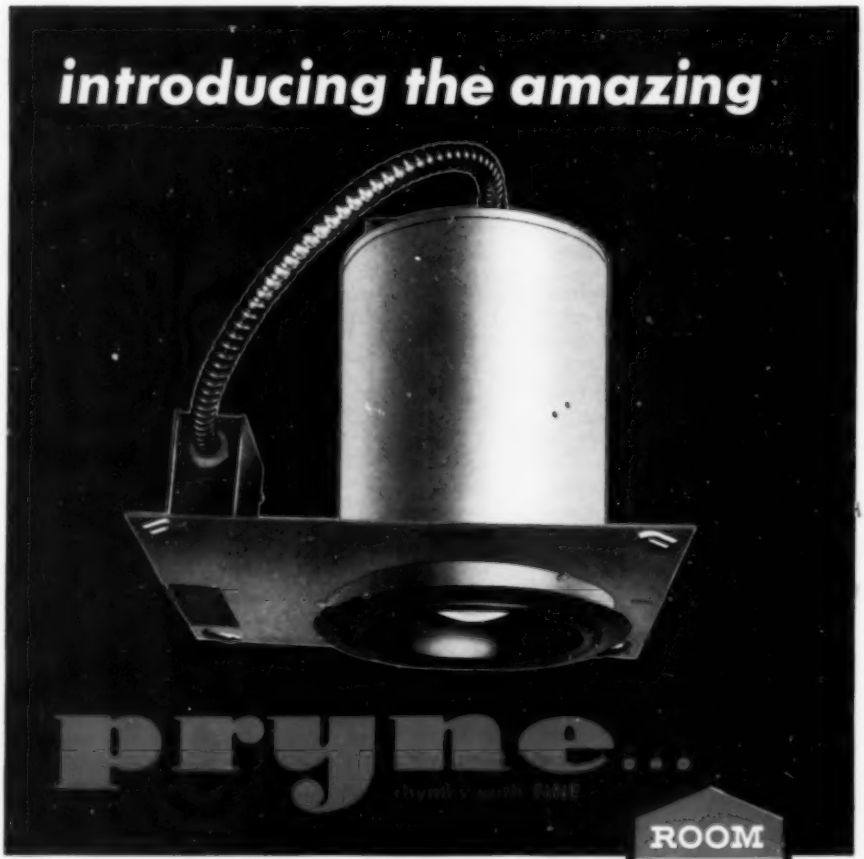
Associate Members:

Haas, W. E., General Electric Co., North Kansas City, Mo.
Purcell, C. J., Benjamin Electric Mfg. Co., Des Plaines, Ill.

INDIANA SECTION

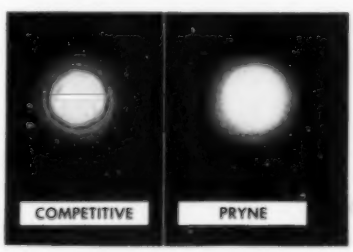
Associate Member:

Lord, W. H., Robert H. Merrill Stage Equipment, Indianapolis, Ind.



EXPANDABLE SPOT LIGHT!

cuts lamp costs from $19.50 to 72c per 3000 hours!



Here is the light that can pay for itself in operating savings alone! Using only a standard 100-W inside frosted lamp, listing at 18¢ and rated for 750 hours, this new Pryne Expandable Spot Light offers tremendous savings over fixtures using lamps listing at $1.30 and rated for 200 hours. Every 3000 hours the savings add up to almost $19 per fixture — not counting the time and labor saved in replacing 11 less lamps!

MANUFACTURERS OF TILTING HOODS · BLO-

MIAMI VALLEY CHAPTER

Member:

Pitzel, Miss Mildred S., Dayton Power & Light Co., Dayton, Ohio.

MICHIGAN SECTION

Member:

Mason, H. R., University of Detroit, Detroit, Mich.

Associate Members:

Hines, D. M., The Detroit Edison Co., Birmingham, Mich.
Hurley, A. H., The Detroit Edison Co., Mt. Clemens, Mich.
Richards, H. E., The Detroit Edison Co., Port Huron, Mich.
Rogers, H. R., The Detroit Edison Co., Lapeer, Mich.
Steininger, R. H., The Detroit Edison Co., Wayne, Mich.
Williams, R. E., Jr., The Detroit Edison Co., Detroit, Mich.
Worden, H. D., The Detroit Edison Co., Ann Arbor, Mich.

MID-SOUTH CHAPTER

Student Members:

Cooper, J. L., Southern College of Optometry, Memphis, Tenn.
Parrish, B. D., Southern College of Optometry, Memphis, Tenn.

MONTREAL SECTION

Associate Members:

Callard, W. E., Callard & Co. Ltd., Montreal, Que.
Ostiguy, Claude, Tasse Sarault & Associates, Montreal, Que.
Vranckx, B. L., Canadian Westinghouse Supply Co., Montreal, Que.

MOTHER LODE CHAPTER

Member:

Storrs, E. E., 2404 E. Poplar, Stockton, Calif.

I.E.S. National Technical Conferences

1956 — September 17-21 — Hotel Statler, Boston, Massachusetts

1957 — September 9-13 — Biltmore Hotel, Atlanta, Georgia

1958 — August 17-22 — Royal York Hotel, Toronto, Ontario

1959 — September 7-11 — Hotels Fairmount and Mark Hopkins, San Francisco, California

NEW ENGLAND SECTION

Member:

Baker, Ervin, Sylvania Electric Products Inc., Salem, Mass.

Associate Members:

Lucas, A. E., Western Massachusetts Electric Co., Pittsfield, Mass.
Wallstrom, R .W., Richard D. Kimball Co., Boston, Mass.
Whitney, R. A., Blackstone Valley Gas & Electric Co., Woonsocket, R. I.

NEW YORK SECTION

Associate Members:

Franco, R. T., General Electric Supply Co., New York, N. Y.
Nelson, J. R., General Electric Supply Co., New York, N. Y.
Sager, Herman, Sperry Gyroscope Co., Lake Success, N. Y.
Schachter, E. J., Century Lighting Inc., New York, N. Y.
Van Schoonhoven, D. B., Century Lighting Inc., New York, N. Y.

NORTHWESTERN OHIO CHAPTER

Associate Member:

Cohen, M. A., Toledo Appliances Inc., Toledo, Ohio.

OHIO VALLEY SECTION

Associate Member:

Shafer, W. E., General Electric Co., Cincinnati, Ohio.

OIL CAPITAL SECTION

Member:

Almond, R., Almond Electric Co., Tulsa, Okla.

Associate Member:

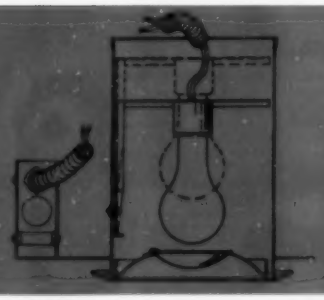
Paschen, W. H., Geo. E. Anderson Co. Tulsa, Okla.

OREGON SECTION

Associate Members:

McCain, R. D., Graybar Electric Co., Portland, Ore.
Toney, W. L., Pacific Power & Light Co., Corvallis, Ore.

(Continued on page 47A)



For narrow beam adjustment, lamp carriage is easily raised by pressing friction slide upward. Wide beam adjustment is accomplished by pulling friction slide downward. No tools required.

FULL BEAM ADJUSTMENT

The Pryne Adjustable Spot Light provides full beam adjustment from 19° to 50°—free of rings, streaks and shadows!

UL APPROVED FOR STANDARD BUILDING WIRE

This is the only fixture of its type that is pre-wired and UL approved for standard building wire!

EASIER RELAMPING AND ADJUSTMENT

Torsion spring front attachment permits easier relamping. Friction slide adjusts beam from wide to narrow—without the use of tools!

pryne

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FANS · PRY-LITES · INFRA-RED CEILING HEATERS

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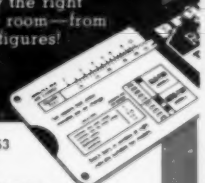
CALCULATOR!

Scientifically compiled, tested for accuracy in Pryne's new Room Rating Laboratory—to help you buy and specify the right lighting for any room—from square footage figures!



PRYNE & CO. INC. Box 153
POMONA, CALIFORNIA

Rush information on the new:

Pryne Expandable Spot Light ☐

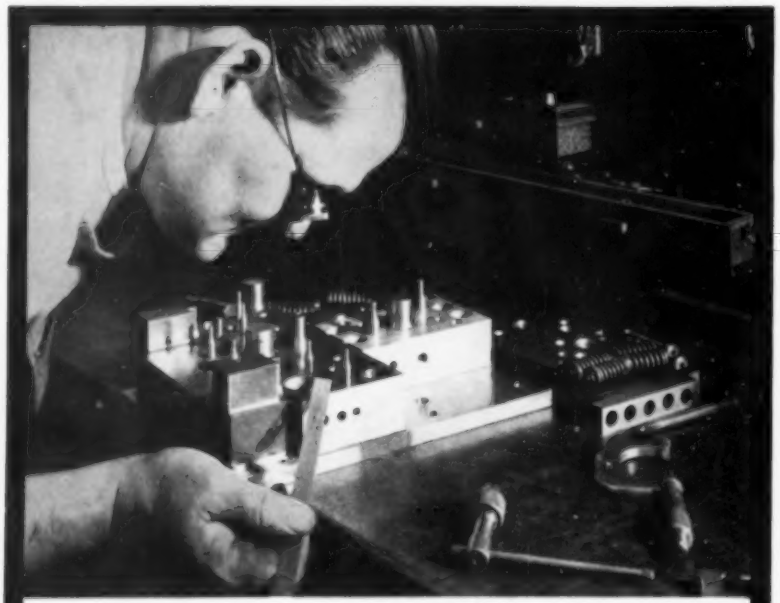
Room Rated Lighting Calculator ☐

Name_____

Company_____

Address_____

City_____ Zone____ State_____



From Dies to Finish, L & P Means Quality!

There's a rare advantage for you in L & P Fluorescent Fixtures—**quality control** that starts with the skilled fabrication of the dies themselves . . . right under our own roof. And the same care and precision work for you every step of the way, giving you "custom-made" quality at the cost of standard fixtures.

Whether you want top quality in regular fixtures, or a special fixture that has to be just right, you'll find the best answer at Light & Power.

For catalog and prices, wire or write today.

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Light & Power Utilities Corp.
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MEMPHIS, TENNESSEE

Employment Opportunities

SALES REPRESENTATIVES WANTED

To sell revolutionary new luminous ceiling and lighting system, fully patented. Choice territories open for experienced lighting men with following among wholesalers, engineers, architects, etc. Address Box 263, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

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Engineering night school student or recent graduate to work for large electric power utility on layouts, economic studies and purchasing of lighting equipment for generating stations and office and service buildings. Experience desired but not essential. Age up to 30. New York City location; some travel required. Give resume of education, experience and references. Address Box 267, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N.Y.

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A well-known Midwestern concern offers excellent opportunity for engineer capable of completely designing Incandescent, Mercury, and Fluorescent Street Lighting Luminaires. Your reply with complete qualifications will be held confidential. Address Box 268, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N.Y.

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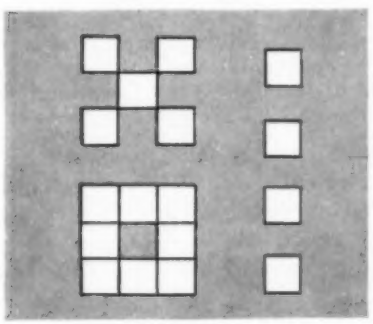

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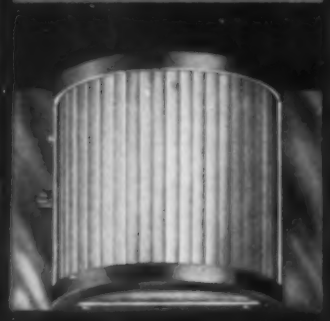

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Here's durability and performance . . . in a distinctive modern design

Striking in its simplicity . . . designed for long-lasting, all-weather protection . . . maximum efficiency, wherever lighting fixtures take a beating.

IT'S MADE OF heavy die-cast aluminum throughout . . . satin-finished . . . anodized for protection against sun, rain, dampness.

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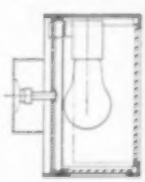

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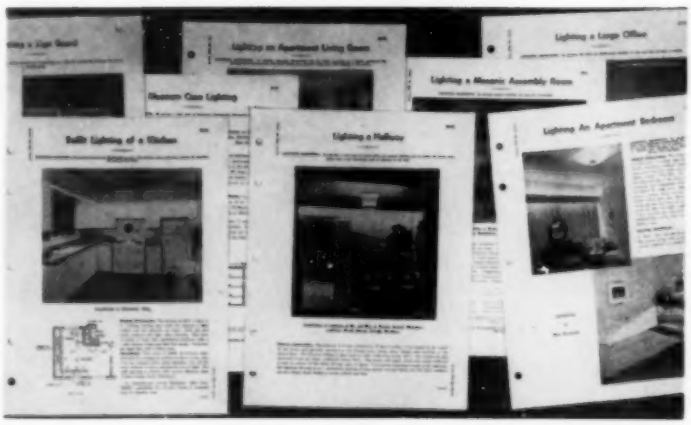

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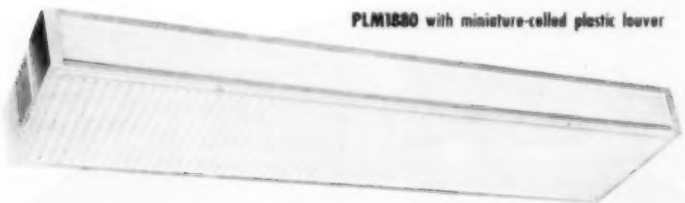
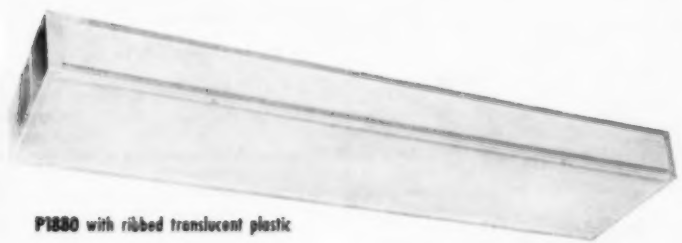


PLM1880 with miniature-celled plastic louver

SUNBEAM Visionaire

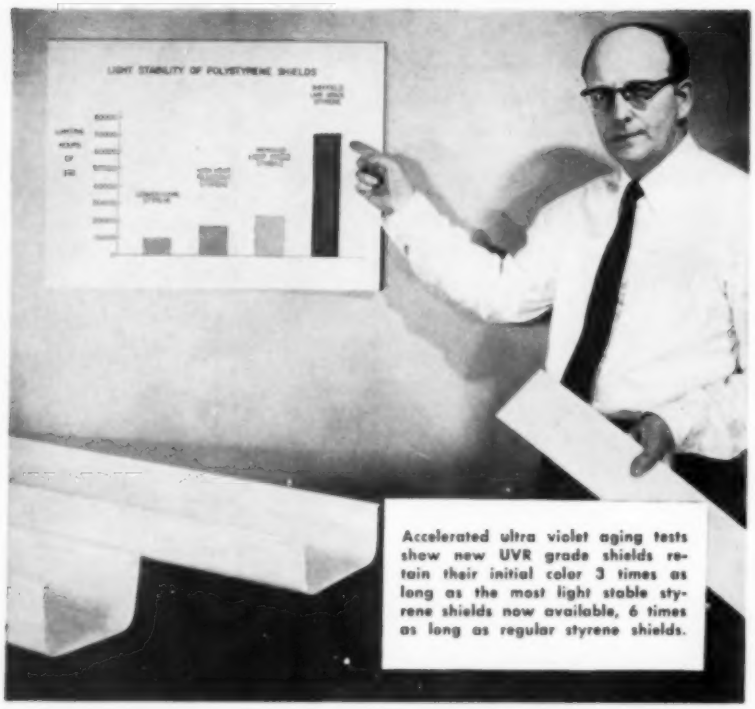
a point you can't afford to miss



P1880 with ribbed translucent plastic

The degree of shallowness in lighting fixture design is limited only by how much you demand uniform low brightness and architectural adaptability. Sunbeam's new, extra-shallow surface-mounted *1880 series Visionaires* represent the practical limit. No exposed ballast enclosures interrupt the smooth appearance of these plastic shielded luminaires. The lamp spacing and distance to diffusers are exactly related to produce even brightness. Unique "hook-on" hinges allow bottom panel to be removed without use of tools. Fully framed bottom-diffuser is a single-element miniature-celled plastic louver or ribbed, translucent Styrene. All metal parts are Bonderite treated and finished in baked white enamel. For further details, please ask for bulletin 739.

SUNBEAM LIGHTING COMPANY
777 EAST 14TH PLACE • LOS ANGELES 21, CALIF.



Accelerated ultra violet aging tests show new UVR grade shields retain their initial color 3 times as long as the most light stable styrene shields now available, 6 times as long as regular styrene shields.

NEW SHEFFIELD SHIELDS HAVE 6 TIMES LIGHT STABILITY OF STANDARD PLASTIC DIFFUSERS

You can now take advantage of the soft, even diffusion of light, plus the beauty, economy, light weight, handling ease and resistance to breakage of plastic shields — with the assurance of their light stability during the useful life of your fluorescent fixtures.

Sheffield's new UVR grade plastic shields are *permanently protected* from the effects of ultra violet light emitted by fluorescent lights. This makes them ideal for troffer units and other fixtures where discoloration spoils appearance.

A special ultra violet absorbing material *permanently combined* with the plastic on the side nearest the light source is the answer. It provides maximum protection where it is needed most, saves you money.

Further, the light stability is achieved with no sacrifice of initial color, hiding power, light transmission, toughness or satin-smooth finish of Sheffield's regular high quality shields.

For full details on the new UVR grade shields, write to Sheffield Plastics Inc., Dept. 161-2B, Sheffield, Mass.

Precision Engineered Rigid Plastic Extrusions

SHEFFIELD PLASTICS
INC.
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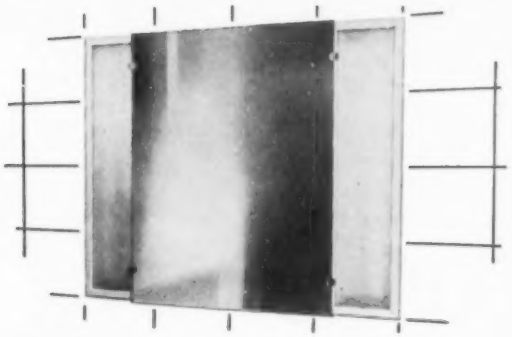
MILWAUKEE FLUORESCENT BATHROOM CABINET



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Bathrooms are *sure to please* when you specify this outstanding combination.

Four 20-watt fluorescent lamps, behind Corning Alba-Lite opal glass, provide glareless, shadowless illumination. No other light needed in most bathrooms.

Roomy cabinet has high-quality polished plate glass mirror, polished-edge glass shelves. All-welded 20-gauge cold rolled steel construction with double-baked white lifetime enamel finish. Fits 30⅛ x 24⅛ x 4 in. wall opening.

See your electrical wholesaler or write for Bulletin 381.

NORTHERN LIGHT COMPANY
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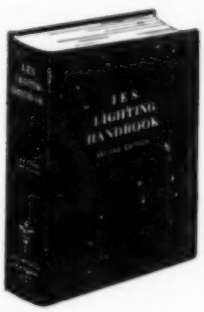

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the answer to "High Ceiling" lighting problems . . .

Where structural conditions in gymnasiums, arenas, auditoriums and the like preclude the use of fully recessed fixtures, Kliegl Surface-mounted Louvered units provide correct, uniform illumination in conformance with today's prescribed requirements.

For situations where exceptionally high ceilings prevail, Suspension Type Louvered fixtures permit installation at the most effective heights above floor level with arrangements for pole relamping, if desired.

Made principally in larger sizes for high wattage lamps, protective louvers guard against accidental damage. These light weight, all-aluminum fixtures, with spun aluminum Alzak finish directional reflectors, offer the advantages of easy installation, and provide the answer to "high ceiling" lighting problems at low cost.

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Architectural Lighting Division

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Originators and Manufacturers of Klieglights

COMFORTABLE, GLARE-FREE ILLUMINATION for the Great Lincoln Shopping Center is provided by this Sola-ballasted, high-intensity fluorescent lighting installation. Each luminaire houses two F100T12 lamps operating from an outdoor, high-output Sola Fluorescent Ballast. Consulting Engineer is Peter W. Bruder; luminaires and standards are by Pfaff & Kendall.

Sola-Ballasted, Fluorescent Lighting Builds Traffic and Business in Great Lincoln Shopping Center

The Great Lincoln Shopping Center, Oceanside, N. Y., illustrates the importance of adequate parking lot lighting. Here, safety and convenience for nighttime shoppers, through high-intensity fluorescent lighting, result in profitable traffic for merchants.

The heart of this installation — maintaining dependable lumen output — is the new outdoor, high-output Sola Fluorescent Ballast. These two-lamp Sola units are helping to reduce operating and maintenance costs to a minimum, too.

Premium performance, at no additional cost, is available when you specify Sola Fluorescent Ballasts for high-intensity lighting applications — street lighting, parking lots, playfields, gasoline stations, and commercial and industrial installations.

If you're concerned with the manufacture, design, operation or maintenance of fluorescent lighting installations, investigate the advantages of Sola Fluorescent Ballasts. Write for the full facts or request a call from your Sola sales engineer.

SOLA *Fluorescent* **BALLASTS**

Write for Bulletin 3C-FL-196A

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CONSTANT VOLTAGE TRANSFORMERS for Regulation of Electronic and Electrical Equipment • **LIGHTING TRANSFORMERS** for All Types of Fluorescent and Mercury Vapor Lamps. • **SOLA ELECTRIC CO., 4633 West 16th Street, Chicago 50, Illinois, Bishop 2-1414** • *NEW YORK 35: 103 E. 125th St., TRafalgar 6-6464* • *PHILADELPHIA: Commercial Trust Bldg., Rittenhouse 6-4988* • *BOSTON: 272 Centre Street, Newton 58, Mass., Bigelow 4-3354* • *CLEVELAND 15: 1836 Euclid Ave., PRospect 1-6400* • *KANSAS CITY 2, MO.: 406 W. 34th St., Jefferson 4382* • *LOS ANGELES 23: 3138 E. Olympic Blvd., ANgelus 9-9431* • *TORONTO 17, ONTARIO: 102 Laird Drive, Mayfair 4554* • *Representatives in Other Principal Cities*

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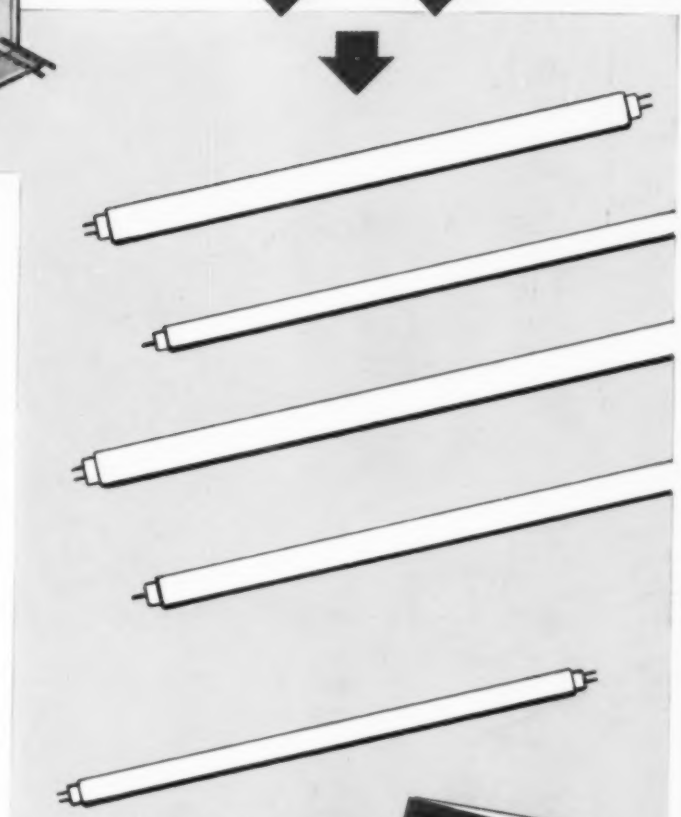
...give you more economical Fluorescent Lighting

because they are "Tailored to the Tube"



Every type and size of fluorescent tube has its own specific electrical requirements. Thus, to get ideal performance and lighting economy, it is essential that the ballasts provide precisely the electrical needs of the tubes they operate.

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Certified CBM Ballasts

PROVIDE:

LONG BALLAST LIFE
FULL LIGHT OUTPUT
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TROUBLE-FREE OPERATION

all of which contribute to easier maintenance and fluorescent lighting economy.

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Send for free booklet, "Why It Pays to Use CERTIFIED CBM BALLASTS in Fluorescent Lighting Fixtures."

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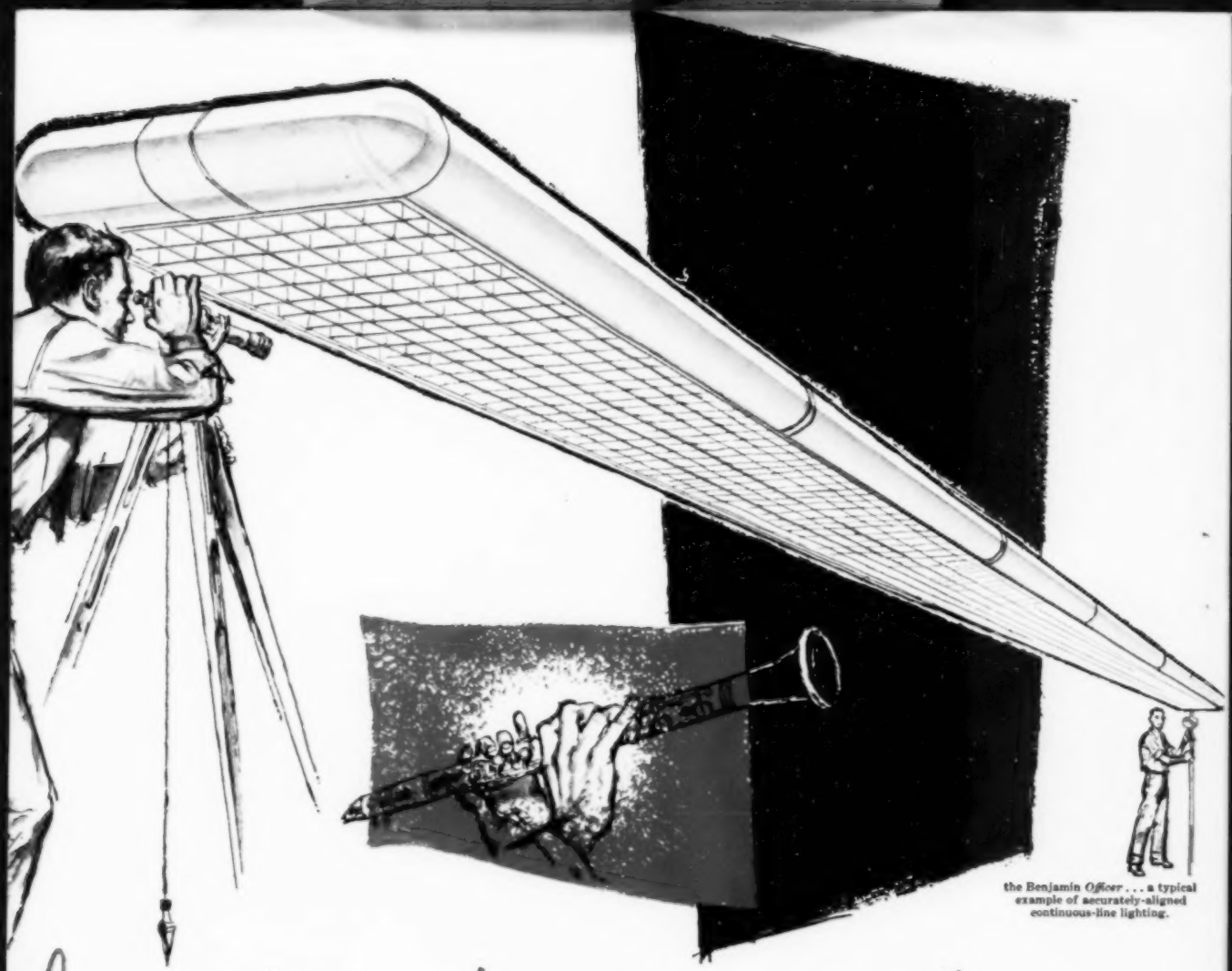
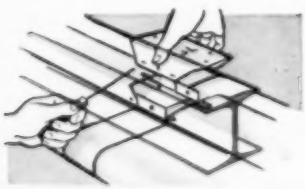


the Benjamin *Officer* . . . a typical example of accurately-aligned continuous-line lighting.

leave the "swing and sway" to Sammy Kaye



I-Beam Rigidity keeps the swing and sway out of continuous-line *Officer* lighting installations.

"Swing and sway" in long rows of fluorescent fixtures is enough to destroy the appearance of any lighting installation. That's why it is engineered *out* of every Benjamin lighting system—be it for a store, office, school or factory.

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One-piece molded louver sections remain distortion-free for the life of the installation.

SUSTAINING MEMBER

Engineering out the swing and sway is just one example of how Benjamin's attention to fine details helps you get maximum benefit from every lighting dollar. It is another reason why experienced electrical specification writers agree: "When all 5 things are considered . . . the better lighting choice is Benjamin." Benjamin Electric Mfg. Co., Dept. 1, Des Plaines, Illinois.

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2 Precision Construction
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